Electronic Supplementary Material (ESI) for Organic and Biomolecular Chemistry

Rapid preparation of triazolyl substituted NH-heterocyclic kinase inhibitors via one-pot Sonogashira coupling–TMS-deprotection–CuAAC sequence**

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Supporting Information

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1. General Considerations

All cross coupling reactions were carried out in oven-dried Schlenk glassware using septa and syringes under nitrogen or argon atmosphere. THF and 1,4-dioxane were dried using *MBraun* system MB-SPS-800, and triethylamine was refluxed under argon atmosphere over ketyl sodium, distilled and stored in a Schlenk flask over potassium hydroxide pellets under argon atmosphere. Dry methanol was purchased from *Sigma-Aldrich Chemie GmbH*.

7-, 6-, and 5-Azaindoles were obtained commercially from *Biosynth*. 4-Azaindole, 4-chloro-7-azaindole, and 4-chloro-deazapurine were synthesized in laboratories of *Merck Serono*, Darmstadt. 4,7-Diazaindole and 2-methyl-7-azaindole were obtained from *Ark Pharm, Inc.* 4(5)-Iodo-1*H*-imidazole and *tert*-butyl 4-iodo-1*H*-pyrazole-1-carboxylate (**1m**) were purchased from *ABCR GmBH & Co.* 4-Bromo-7-azaindole (**6a**) and 5-bromo-7-azaindole (**6b**) were obtained from *Sigma-Aldrich Chemie GmbH.*

Trimethylsilylacetylene was obtained from *Sigma-Aldrich Chemie GmbH.* Tetrabutylammonium fluoride (1 M in THF) was obtained from *Sigma-Aldrich Chemie GmbH*. Benzyl azide (**5a**) was obtained from *ABCR GmBH & Co*. Azidobenzene solution (~ 0.5 M in *tert*-butylmethylether) was obtained from *Sigma-Aldrich Chemie GmbH*. Cesium azide was obtained from *Sigma-Aldrich Chemie GmbH*. Cp*RuCl(PPh_3)$_2$ was obtained from *ABCR GmBH & Co*.

Commercial grade reagents were used as supplied without further purification and were purchased from *Acros Organics*, *Sigma-Aldrich Chemie GmbH*, *Fluka AG*, *ABCR GmBH & Co. KG, AppliChem,* and *Merck KGaA*.

The purification of products was performed on silica gel 60 (0.015-0.040 mm) from *Merck KGaA* using flash technique and under pressure of 2 bar. The crude mixtures were adsorbed on Celite 545 (0.02-0.10 mm) from *Merck KGaA* before chromatographic purification.

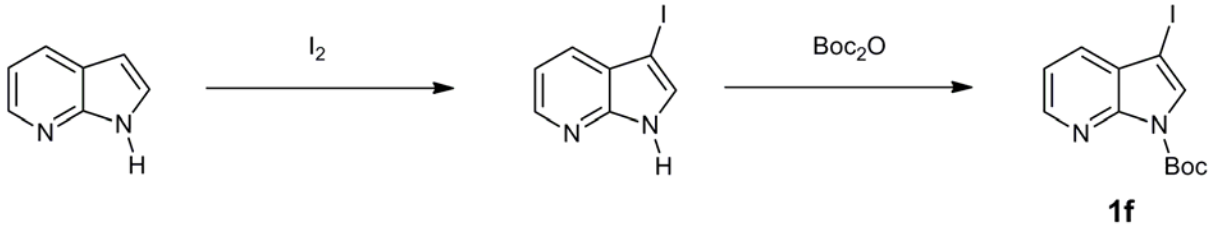
The reaction progress was monitored qualitatively using TLC Silica gel 60 F_{254} 5 x 7.5 cm aluminium sheets obtained by *Merck KGaA*. The spots were detected with UV light at 254 nm and using aqueous potassium permanganate solution.

^{1}H, ^{13}C, and 135-DEPT NMR spectra were recorded on Bruker DRX 500 spectrometer. $CDCl_3$ and DMSO-d_6 were used as deuterated solvents. TMS was used as reference (δ = 0.0) or the resonances of the solvents were locked as internal standards ($CDCl_3$: ^{1}H δ 7.26, ^{13}C δ 77.0; DMSO-d_6: ^{1}H δ 2.50, ^{13}C δ 39.4). The multiplicities of signals were abbreviated as follows: s: singlet; d: doublet; t: triplet; dd: doublet of doublets, q: quartet, m: multiplet and br: broad signal. The type of carbon atoms was determined on the basis of 135-DEPT NMR spectra.

EI mass spectra were measured on Finnigan MAT 8200 spectrometer. IR spectra were obtained on Bruker Vector 22 FT-IR. The solids were measured as KBr pellets and oils as films on KBr plates. The intensity of signals is abbreviated as follows: s (strong), m (medium) and w (weak). The melting points (uncorrected) were measured on Reichert-Jung Thermovar. Combustion analyses were carried out on Perkin Elmer Series II Analyser 2400 in the microanalytical laboratory of Institut für Pharmazeutische und Medizinische Chemie der Heinrich-Heine-Universität Düsseldorf. HT-LC-MS spectra were measured in the Molecule Analytics laboratory of Central Analytical Services, *Merck KGaA* Darmstadt. The content of Pd and Cu in the compound **8f** was determined in the Element Analytics laboratory of Central Analytical Services, *Merck KGaA* Darmstadt.

2. Preparation of Starting Materials 1a-l and 1n

2.1. Preparation of N-Boc 3-iodo (aza)indoles 1a, 1d-k, and 1n (shown for tert-butyl 3-iodo-1H-pyrrolo[2,3-b]pyridine-1-carboxylate (1f))[1]



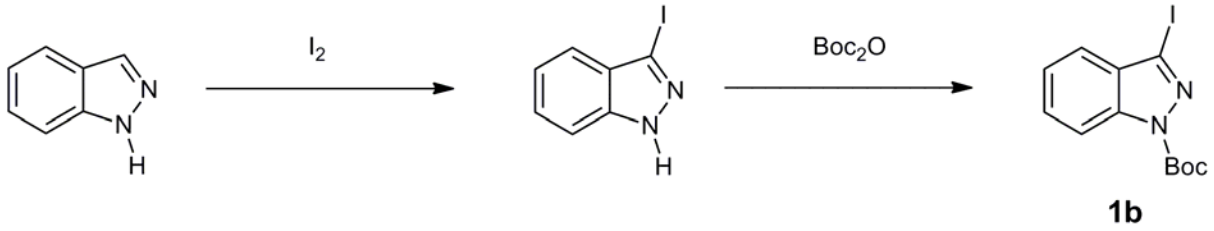
1f

A solution of iodine (25.7 g, 101 mmol, 1.01 equiv) in 180 mL of DMF was dropped to the solution of 7-azaindole (12.1 g, 100 mmol) and potassium hydroxide (16.5 g, 250 mmol, 2.50 equiv) in 180 mL of DMF at room temperature and the mixture was stirred for 45 min. The reaction mixture was then poured on 1 L ice water containing 1 % ammonia and 0.2 % sodium disulfite. The precipitate was filtered, washed with ice water and dried in vacuo to obtain 23.7 g (97.2 mmol, 97 % yield) of a yellow solid.
The obtained iodide was used without further purification in the next step. It was suspended in 180 mL of dichloromethane, 4-dimethylaminopyridine (1.21 g, 9.72 mmol, 10 mol %) was added and di-*tert*-butyl dicarbonate (32.8 g, 146 mmol, 1.50 equiv), dissolved in 180 mL of dichloromethane, was added dropwise over 30 min. The mixture was stirred for 30 min at room temperature, washed with 200 mL of 0.1 N HCl, and the aqueous phase was extracted with dichloromethane (2 x 100 mL). The combined organic layers were dried with sodium sulphate, the solvents were removed under reduced pressure and the residue was adsorbed onto Celite® and purified chromatographically on silica gel with petroleum ether (boiling range 40-60 °C)/ethyl acetate (PE-EtOAc = 20:1, R_f (PE-EtOAc = 20:1): 0.14) to give 31.6 g (91.8 mmol, 94 % yield; 92 % total yield over two steps) of *tert*-butyl 3-iodo-1*H*-pyrrolo[2,3-*b*]pyridine-1-carboxylate (**1f**) as an orange oil, which solidifies upon storage in refrigerator.

Compounds **1a**, **1d**-**e**, **1g**-**k**, and **1n** were obtained analogously.

The experimental details are depicted in ***Table 1***.

2.2. Preparation of tert-butyl 3-iodo-1H-indazole-1-carboxylate (1b)

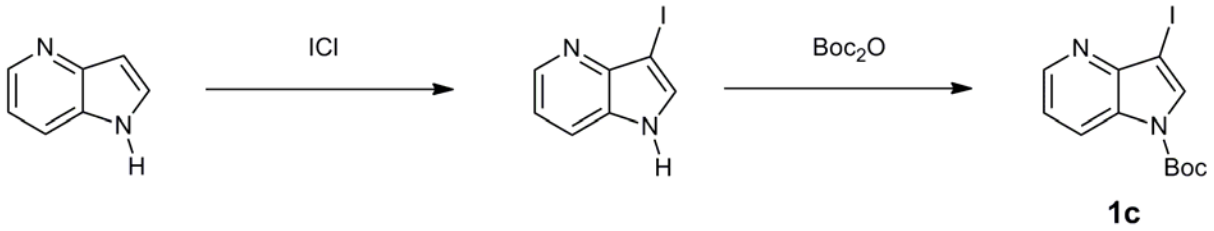


1b

A solution of iodine (13.8 g, 54.3 mmol, 2.00 equiv) in 50 mL of DMF was dropped to the solution of 1*H*-indazole (3.34 g, 27.1 mmol) and potassium hydroxide (5.70 g, 102 mmol, 3.76 equiv) in 50 mL of DMF at room temperature and the mixture was stirred for 4 h. The reaction mixture was then poured onto 200 mL of saturated sodium silfite solution and extracted with diethylether (2 x 50 mL). The combined organic layers were washed with water and brine and dried with sodium sulphate. After the solvents were removed under reduced pressure, 6.09 g (24.9 mmol, 92 % yield) of a yellow solid were obtained.

The obtained iodide was used without further purification for the next step. 3-Iodo-1*H*-indazole (5.09 g, 20.9 mmol) was dissolved in 100 mL of dichloromethane, then triethylamine (27.2 mL, 196 mmol, 9.39 equiv) and 4-dimethylaminopyridine (261 mg, 2.09 mmol, 10 mol %) were added, and di-*tert*-butyl dicarbonate (14.1 g, 62.6 mmol, 3.00 equiv), dissolved in 50 mL of dichloromethane, was slowly added dropwise. The mixture was stirred for 4 h at room temperature, washed with saturated sodium sulfite solution (3 x 20 mL), dried with sodium sulphate, and the solvents were removed under reduced pressure. The residue was adsorbed onto Celite® and purified chromatographically on basic Alox with petroleum ether (boiling range 40-60 °C)/ethyl acetate (PE-EtOAc = 20:1, R_f (PE-EtOAc = 20:1): 0.31) to give 6.26 g (18.2 mmol, 87 % yield; 80 % total yield over two steps) of *tert*-butyl 3-iodo-1*H*-indazole-1-carboxylate (**1b**) as a pale yellow solid.

2.3. Preparation of tert-butyl 3-iodo-1H-pyrrolo[3,2-b]pyridine-1-carboxylate (1c)[2]



1c

4-Azaindole (11.8 g, 100 mmol) was dissolved in 200 mL of pyridine and the solution was cooled with an ice bath. Then, 220 mL of a 0.5 M solution of iodomonochloride (17.9 g, 110 mmol, 1.10 equiv) in dichloromethane was added over 5 min. After 15 min the cooling bath was removed, and after another 30 min the solution was diluted with 2 L of ethyl acetate. The mixture was washed successively with 1 N HCL and 1 N NaOH, dried with sodium sulphate, and the solvents were removed in vacuo. The residue was dried in vacuo to give 18.3 g (75.0 mmol, 75 %) of an orange solid.

The obtained iodide was used without further purification for the next step. 3-Iodo-1*H*-pyrrolo[3,2-*b*]pyridine (1.82 g, 7.45 mmol) was dissolved in 30 mL of dichloromethane, then triethylamine (6.62 mL, 47.8 mmol, 6.41 equiv) and 4-dimethylaminopyridine (91 mg, 0.75 mmol, 10 mol %) were added, and di-*tert*-butyl dicarbonate (3.25 g, 14.9 mmol, 2.00 equiv), dissolved in 25 mL of dichloromethane, was slowly added dropwise. The mixture was stirred for 4 h at room temperature, washed with saturated sodium sulfite solution (2 x 20 mL), dried with sodium sulphate, and the solvents were removed under reduced pressure. The residue was adsorbed onto Celite® and purified chromatographically on neutral Alox with petroleum ether (boiling range 40-60 °C)/ethyl acetate (PE-EtOAc = 5:1, R_f (PE-EtOAc = 5:1): 0.41) to give 1.88 g (5.45 mmol, 73 % yield; 55 % total yield over two steps) of *tert*-butyl 3-iodo-1*H*-pyrrolo[3,2-*b*]pyridine-1-carboxylate (**1c**) as a colorless solid.

Table 1. *Experimental details for the synthesis of N-Boc 3-iodo (aza)indoles* ***1a-k*** *and N-Boc 4-iodo imidazole* ***1n****.*

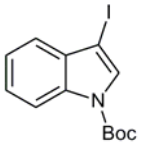
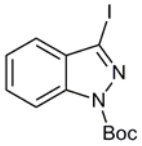
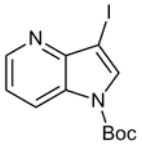
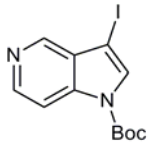
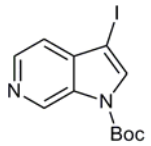
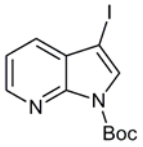
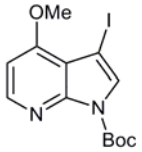
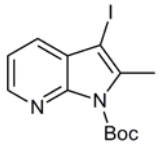
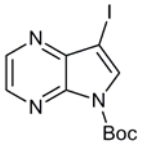
Entry	(Aza)Indole	3-Iodo (aza)indole	*N*-Boc 3-Iodo (aza)indole **1** (isolated yield %)	Chromatographic purification (eluent) R_f (eluent)
1	20.0 g (171 mmol) 1*H*-Indole (*Acros*)	Yellow solid 32.8 g (135 mmol, 79 %) For Boc-protection: 10.0 g (41.1 mmol)	Brown oil 11.3 g (32.9 mmol, 80 %) Total yield: 63 %  **1a**	PE-EtOAc = 50:1 R_f (PE-EtOAc = 50:1): 0.38
2	3.34 g (27.1 mmol) 1*H*-Indazole (*ABCR*)	Yellow solid 6.09 g (24.9 mmol, 92 %) For Boc-protection: 5.09 g (20.9 mmol)	Colorless solid 6.26 g (18.2 mmol, 87 %) Total yield: 80 %  **1b**	PE-EtOAc = 20:1 R_f (PE-EtOAc = 20:1): 0.31
3	11.8 g (100 mmol) 1*H*-Pyrrolo[3,2-*b*]pyridine (4-Azaindole) (*Biosynth*)	Orange solid 18.3 g (75.0 mmol, 75 %) For Boc-protection: 1.82 g (7.45 mmol)	Colorless solid 1.88 g (5.45 mmol, 73 %) Total yield: 55 %  **1c**	PE-EtOAc = 5:1 R_f (PE-EtOAc = 5:1): 0.41

Table 1 (continuation). *Experimental details for the synthesis of N-Boc 3-iodo (aza)indoles* ***1a-k*** *and N-Boc 4-iodo imidazole* ***1n****.*

Entry	Azaindole	3-Iodo azaindole	*N*-Boc 3-Iodo azaindole **1** (isolated yield %)	Chromatographic purification (eluent) R_f (eluent)
4	1.00 g (8.47 mmol) 1*H*-Pyrrolo[3,2-*c*]pyridine (5-Azaindole) (*Biosynth*)	Pale yellow solid 1.50 g (6.14 mmol, 73 %)	Colorless solid 1.85 g (5.36 mmol, 87 %) Total yield: 64 %  **1d**	PE-EtOAc = 2:1 R_f (PE-EtOAc = 2:1): 0.37
5	5.00 g (42.3 mmol) 1*H*-Pyrrolo[2,3-*c*]pyridine (6-Azaindole) (*Biosynth*)	Yellow solid 8.10 g (33.2 mmol, 78 %) For Boc-protection: 7.11 g (29.1 mmol)	Pale yellow solid 7.52 g (21.9 mmol, 75 %) Total yield: 59 %  **1e**	PE-EtOAc = 2:1 R_f (PE-EtOAc = 2:1): 0.36
6	12.1 g (100 mmol) 1*H*-Pyrrolo[2,3-*b*]pyridine (7-Azaindole) (*ABCR*)	Yellow solid 23.7 g (97.2 mmol, 97 %)	Yellow-orange oil[a] 31.6 g (91.8 mmol, 94 %) Total yield: 92 %  **1f**	PE-EtOAc = 20:1 R_f (PE-EtOAc = 20:1): 0.14

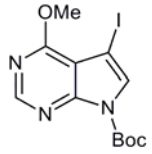
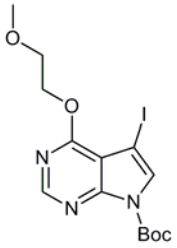
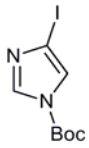
[a] Solidifies upon storage in refrigerator.

Table 1 (continuation). *Experimental details for the synthesis of N-Boc 3-iodo (aza)indoles* ***1a-k*** *and N-Boc 4-iodo imidazole* ***1n****.*

Entry	Azaindole	3-Iodo azaindole	*N*-Boc 3-Iodo azaindole **1** (isolated yield %)	Chromatographic purification (eluent) R_f (eluent)
7	284 mg (1.92 mmol) 4-Methoxy-1*H*-pyrrolo[2,3-*b*]pyridine[a]	Yellow solid 420 mg (1.53 mmol, 80 %) For Boc-protection: 385 mg (1.40 mmol)	Colorless solid 428 mg (1.14 mmol, 82 %) Total yield: 65 %  **1g**	PE-EtOAc = 1:1 R_f (PE-EtOAc = 1:1): 0.51
8	2.50 g (18.0 mmol) 2-Methyl-1*H*-pyrrolo[2,3-*b*]pyridine (*Ark Pharm*)	Beige solid 4.33 g (16.8 mmol, 93 %) For Boc-protection: 4.25 g (16.5 mmol)	Yellow oil[b] 5.58 g (15.6 mmol, 95 %) Total yield: 88 %  **1h**	PE-EtOAc = 20:1 → 15:1 R_f (PE-EtOAc = 15:1): 0.44
9	1.25 g (10.0 mmol) 5*H*-Pyrrolo[2,3-*b*]pyrazine (4,7-Diaza-indole) (*Ark Pharm*)	Yellow solid 2.00 g (8.18 mmol, 82 %) For Boc-protection: 1.96 g (7.99 mmol)	Pale yellow solid 2.53 g (7.33 mmol, 92 %) Total yield: 75 %  **1i**	PE-EtOAc = 5:1 R_f (PE-EtOAc = 5:1): 0.31

[a] Preparation from 4-chloro-1*H*-pyrrolo[2,3-*b*]pyridine is described in S. Benoit, S. Gingras, N. Soundararajan, PCT Int. Appl. 2003, WO 2003082289 A1 20031009. The beige solid was obtained in 78 % yield.
[b] Solidifies upon storage in refrigerator.

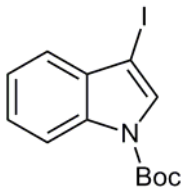
Table 1 (continuation). *Experimental details for the synthesis of N-Boc 3-iodo (aza)indoles* ***1a-k*** *and N-Boc 4-iodo imidazole* ***1n****.*

Entry	Azaindole	3-Iodo azaindole	*N*-Boc 3-Iodo azaindole **1** (isolated yield %)	Chromatographic purification (eluent) R_f (eluent)
10	611 mg (4.10 mmol) 4-Methoxy-7*H*-pyrrolo[2,3-*d*]pyrimidine[a]	Pale yellow solid 897 mg (3.26 mmol, 80 %)	Colorless solid 1.12 g (2.98 mmol, 91 %) Total yield: 73 %  **1j**	PE-EtOAc = 5:1 R_f (PE-EtOAc = 5:1): 0.38
11	966 mg (5.00 mmol) 4-(2-Methoxyethoxy)-7*H*-pyrrolo[2,3-*d*]pyrimidine[b]	Pale yellow solid 1.33 g (4.15 mmol, 83 %) For Boc-protection: 1.26 g (3.95 mmol)	Pale yellow oil 1.55 g (3.70 mmol, 94 %) Total yield: 78 %  **1k**	PE-EtOAc = 5:1 → 4:1 R_f (PE-EtOAc = 5:1): 0.22
12		2.06 g (10.0 mmol) 4(5)-Iodo-1*H*-imidazole (*ABCR*)	Yellow oil 2.71 g (9.23 mmol, 92 %)[c]  **1n**	PE-EtOAc = 20:1 R_f (PE-EtOAc = 20:1): 0.16

[a] Preparation from 4-chloro-7*H*-pyrrolo[2,3-*d*]pyrimidine as described for 4-methoxy-7-azaindole in S. Benoit, S. Gingras, N. Soundararajan, PCT Int. Appl. 2003, WO 2003082289 A1 20031009. The colorless solid was obtained in 76 % yield.
[b] Preparation from 4-chloro-7*H*-pyrrolo[2,3-*d*]pyrimidine upon refluxing with 2.5 equivs of Cs_2CO_3 in 2-methoxyethanol (*c* = 0.2 M) as a colorless solid in 85 % yield.
[c] The isomer, *tert*-butyl 5-iodo-1*H*-imidazole-1-carboxylate, was obtained along with **1n** as a yellow solid in 4 % yield (123 mg, 0.42 mmol).

2.4. Spectroscopic data of compounds 1a-k and 1n

2.4.1. tert-Butyl 3-iodo-1*H*-indole-1-carboxylate (1a)



$C_{13}H_{14}INO_2$

343.16

11.3 g (32.9 mmol, 63 % yield over two steps) as a pale brown oil. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.66 (s, 9 H), 7.28-7.32 (m, 1 H), 7.33-7.36 (m, 1 H), 7.36-7.40 (m, 1 H), 7.72 (s, 1 H), 8.12 (d, *J* = 7.3 Hz, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 28.1 (CH_3), 65.4 (C_{quat}), 84.2 (C_{quat}), 115.0 (CH), 121.4 (CH), 123.3 (CH), 125.3 (CH), 130.0 (CH), 132.0 (C_{quat}), 134.8 (C_{quat}), 148.6 (C_{quat}). EI + MS (*m/z* (%)): 343 (M^+, 14), 287 ($(M-C_4H_9+H)^+$, 59), 270 ($(M-C_4H_9O+H)^+$, 6), 243 ($(M-C_5H_9O_2+H)^+$, 79), 116 ($C_8H_6N^+$, 30), 115 ($C_8H_5N^+$, 22), 88 (10), 57 ($C_4H_9^+$, 100), 41 (13). Anal. calcd for $C_{13}H_{14}INO_2$ (343.2): C 45.50, H 4.11, N 4.08. Found: C 45.24, H 4.30, N 3.89.

Data reported in the literature:

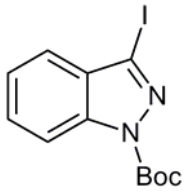
B. Witulski, N. Buschmann, U. Bergsträßer, *Tetrahedron* **2000**, *56*, 8473-8480.

Colorless solid (*n*-pentane). Mp 36-40 °C. ^{1}H NMR (400 MHz): δ 1.68 (s, 9 H), 7.29-7.43 (m, 3 H), 7.73 (s, 1 H), 8.13 (d, *J* = 8.1 Hz, 1 H). ^{13}C NMR (100 MHz): δ 28.1 (q), 65.4 (s), 115.1 (d), 121.5 (d), 123.3 (d), 125.3 (d), 130.1 (d), 132.1 (s), 134.9 (s), 148.7 (s). EI + MS (*m/z* (%)): 343 (M^+, 69), 287 (100), 270 (13), 243 (98), 116 (28), 57 (98). Anal. calcd for $C_{13}H_{14}INO_2$ (343.2): C 45.50, H 4.11, N 4.08. Found: C 45.37, H 3.66, N 3.96.

T. A. Kelly, D. W. McNeil, J. M. Rose, E. David, C.-K. Shih, P. M. Grob, *J. Med. Chem*. **1997**, *40*, 2430-2433.

^{1}H NMR ($CDCl_3$): δ 1.69 (s, 9 H), 7.20-7.41 (m, 3 H), 7.72 (s, 1 H), 8.15 (d, *J* = 5.0 Hz, 1 H).

2.4.2. tert-Butyl 3-iodo-1*H*-indazole-1-carboxylate (1b)



$C_{12}H_{13}IN_2O_2$

344.15

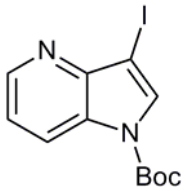
6.26 g (18.2 mmol, 80 % yield over two steps) as a colorless solid. Mp 117 °C. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.73 (s, 9 H), 7.34-7.39 (m, 1 H), 7.47-7.51 (m, 1 H), 7.56-7.61 (m, 1 H), 8.11 (d, *J* = 8.5 Hz, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 28.1 (CH_3), 85.4 (C_{quat}), 102.9 (C_{quat}), 114.5 (CH), 121.9 (CH), 124.1 (CH), 129.9 (CH), 130.1 (C_{quat}), 139.5 (C_{quat}), 148.3 (C_{quat}). EI + MS (*m/z* (%)): 344 (M^+, 21), 244 ((M-C_4H_9+H-CO_2)$^+$, 100), 117 ($C_7H_5N_2^+$, 13), 58 (11), 57 ($C_4H_9^+$, 61), 43 (14). Anal. calcd for $C_{12}H_{13}IN_2O_2$ (344.2): C 41.88, H 3.81, N 8.14. Found: C 42.11, H 4.03, N 8.01.

Data reported in the literature:

J. Vazquez, S. K. De, L.-H. Chen, M. Riel-Mehan, A. Emdadi, J. Cellitti, J. L. Stebbins, M. F. Rega, M. Pellecchia, *J. Med. Chem.* **2008**, *51*, 3460-3465.

^{1}H NMR ($CDCl_3$, 300 MHz): δ 1.72 (s, 9 H), 7.37 (t, *J* = 8.1 Hz, 1 H), 7.49 (d, *J* = 8.1 Hz, 1 H), 7.58 (t, *J* = 7.5 Hz, 1 H), 8.11 (d, *J* = 8.7 Hz, 1 H). MS (*m/z*): 367 (M+Na)$^+$, 345 (M+H)$^+$, 310, 289, 244, 124, 74, 56. HRMS calcd for $C_{12}H_{14}IN_2O_2$ (M+H): 345.0100. Found 345.0095.

2.4.3. tert-Butyl 3-iodo-1*H*-pyrrolo[3,2-*b*]pyridine-1-carboxylate (1c)

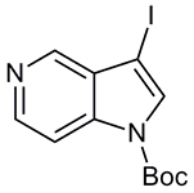


$C_{12}H_{13}IN_2O_2$

344.15

1.88 g (5.45 mmol, 55 % yield over two steps) as a colorless solid. Mp 125 °C. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.68 (s, 9 H), 7.30 (dd, *J* = 8.5 Hz, *J* = 4.7 Hz, 1 H), 7.98 (s, 1 H), 8.4 (br, 1 H), 8.62 (dd, *J* = 4.7 Hz, *J* = 1.6 Hz, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 28.1 (CH_3), 67.7 (C_{quat}), 85.2 (C_{quat}), 119.9 (CH), 122.6 (CH), 128.3 (C_{quat}), 132.8 (CH), 146.4 (CH), 147.9 (C_{quat}), 148.2 (C_{quat}). EI + MS (*m/z* (%)): 344 (M^+, 33), 288 ($(M-C_4H_9+H)^+$, 85), 244 ($(M-C_4H_9+H-CO_2)^+$, 81), 57 ($C_4H_9^+$, 100). Anal. calcd for $C_{12}H_{13}IN_2O_2$ (344.2): C 41.88, H 3.81, N 8.14. Found: C 42.04, H 4.06, N 8.04.

2.4.4. tert-Butyl 3-iodo-1*H*-pyrrolo[3,2-*c*]pyridine-1-carboxylate (1d)



$C_{12}H_{13}IN_2O_2$

344.15

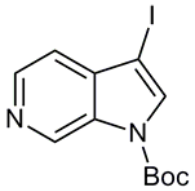
1.85 g (5.36 mmol, 64 % yield over two steps) as a colorless solid. Mp 119 °C. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.68 (s, 9 H), 7.73 (s, 1 H), 7.95 (br, 1 H), 8.54 (d, *J* = 5.7 Hz, 1 H), 8.71 (s, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 28.0 (CH_3), 62.1 (C_{quat}), 85.5 (C_{quat}), 109.5 (CH), 128.1 (C_{quat}), 130.8 (CH), 139.7 (C_{quat}), 144.5 (CH), 145.1 (CH), 148.0 (C_{quat}). EI + MS (*m/z* (%)): 344 (M^+, 11), 288 ((M-C_4H_9+H)$^+$, 36), 244 ((M-C_4H_9+H-CO_2)$^+$, 65), 117 ($C_7H_5N_2^+$, 15), 116 ($C_7H_4N_2^+$, 7), 57 ($C_4H_9^+$, 100), 41 (13). Anal. calcd for $C_{12}H_{13}IN_2O_2$ (344.2): C 41.88, H 3.81, N 8.14. Found: C 42.13, H 3.82, N 8.13.

Data reported in the literature:

M. Lefoix, J.-P. Daillant, S. Routier, J.-Y. Mérour, I. Gillaizeau, G. Coudert, *Synthesis* **2005**, 3581-3588.

White solid. R_f (PE-EtOAc = 6:4): 0.3. Mp 127-128 °C. ^{1}H NMR ($CDCl_3$, 250 MHz): δ 1.68 (s, 9 H, $C(CH_3)_3$), 7.73 (s, 1 H, H-2), 7.95 (dd, *J* = 5.7 Hz, *J* = 0.9 Hz, 1 H, H-6), 8.55 (d, *J* = 5.7 Hz, 1 H, H-7), 8.71 (d, *J* = 0.9 Hz, 1 H, H-4). ^{13}C NMR ($CDCl_3$, 62.5 MHz): δ 28.2 ($C(CH_3)_3$), 62.2 (C-I), 85.7 ($C(CH_3)_3$), 109.7 (CH-6), 128.3 (C_{quat}), 131.0 (CH-2), 139.8 (C_{quat}), 144.6 (CH-4), 145.1 (CH-7), 148.2 (*t*-BuOOC). EI + MS (*m/z* (%)): 345 (MH^+, 92), 289 ((MH-*t*-Bu)$^+$, 100), 245 ((MH-Boc)$^+$, 29). IR (KBr): $\tilde{\nu}$ 2982 cm^{-1}, 1746, 1168. HRMS (EI) *m/z* calcd for $C_{12}H_{13}IN_2O_2$: 344.00218; found: 344.0021.

2.4.5. tert-Butyl 3-iodo-1*H*-pyrrolo[2,3-*c*]pyridine-1-carboxylate (1e)

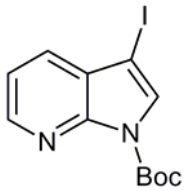


$C_{12}H_{13}IN_2O_2$

344.15

7.52 g (21.9 mmol, 59 % yield over two steps) as a pale yellow solid. Mp 149-150 °C. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.70 (s, 9 H), 7.38 (d, *J* = 5.4 Hz, 1 H), 7.90 (s, 1 H), 8.51 (d, *J* = 5.4 Hz, 1 H), 9.37 (s, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 28.0 (CH_3), 63.4 (C_{quat}), 85.9 (C_{quat}), 115.8 (CH), 131.8 (C_{quat}), 133.5 (CH), 136.8 (CH), 138.3 (C_{quat}), 141.8 (CH), 147.7 (C_{quat}). EI + MS (*m/z* (%)): 344 (M^+, 13), 288 ($(M-C_4H_9+H)^+$, 27), 244 ($(M-C_4H_9+H-CO_2)^+$, 100), 117 ($C_7H_5N_2^+$, 22), 116 ($C_7H_4N_2^+$, 11), 90 (10), 57 ($C_4H_9^+$, 100), 41 (13). Anal. calcd for $C_{12}H_{13}IN_2O_2$ (344.2): C 41.88, H 3.81, N 8.14. Found: C 42.13, H 3.93, N 8.01.

2.4.6. tert-Butyl 3-iodo-1*H*-pyrrolo[2,3-*b*]pyridine-1-carboxylate (1f)



$C_{12}H_{13}IN_2O_2$

344.15

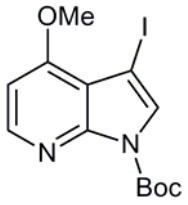
31.6 g (91.8 mmol, 92 % yield over two steps) as a yellow oil (solidified upon storage in refrigerator). Mp 79 °C. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.66 (s, 9 H), 7.22 (dd, *J* = 7.9 Hz, *J* = 4.7 Hz, 1 H), 7.61 (dd, *J* = 7.9 Hz, *J* = 1.6 Hz, 1 H), 7.78 (s, 1 H), 8.50 (dd, *J* = 4.7 Hz, *J* = 1.6 Hz, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 27.4 (CH_3), 61.3 (C_{quat}), 83.8 (C_{quat}), 118.5 (CH), 124.3 (C_{quat}), 128.9 (CH), 129.9 (CH), 145.3 (CH), 146.0 (C_{quat}), 146.6 (C_{quat}). EI + MS (*m/z* (%)): 344 (M^+, 4), 245 (8), 244 ((M-$C_5H_9O_2$+H)$^+$, 100), 117 ($C_7H_5N_2^+$, 23), 116 ($C_7H_4N_2^+$, 10), 90 (10), 57 ($C_4H_9^+$, 26).

Data reported in the literature:

T. A. Kelly, D. W. McNeil, J. M. Rose, E. David, C.-K. Shih, P. M. Grob, *J. Med. Chem*. **1997**, *40*, 2430-2433.

^{1}H NMR ($CDCl_3$): δ 1.70 (s, 9 H), 7.28 (dd, *J* = 8.5 Hz, 1 H), 7.72 (dd, *J* = 8.1 Hz, 1 H), 7.80 (s, 1 H), 8.49 (dd, *J* = 5.1 Hz, 1 H).

2.4.7. tert-Butyl 3-iodo-4-methoxy-1*H*-pyrrolo[2,3-*b*]pyridine-1-carboxylate (1g)

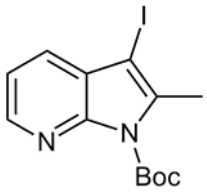


$C_{13}H_{15}IN_2O_3$

374.17

428 mg (1.14 mmol, 65 % yield over two steps) as a colorless solid. Mp 122 °C. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.65 (s, 9 H), 3.99 (s, 3 H), 6.67 (d, J = 5.7 Hz, 1 H), 7.63 (s, 1 H), 8.40 (d, J = 5.7 Hz, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 28.0 (CH_3), 54.6 (C_{quat}), 55.5 (CH_3), 84.6 (C_{quat}), 101.0 (CH), 112.8 (C_{quat}), 129.7 (CH), 146.8 (C_{quat}), 147.8 (CH), 149.0 (C_{quat}), 160.1 (C_{quat}). EI + MS (*m/z* (%)): 374 (M^+, 5), 301 ((M-$C_4H_9O)^+$, 2), 274 ((M-$C_5H_9O_2$+H)$^+$, 61), 273 ((M-$C_5H_9O_2)^+$, 13), 259 ((M-$C_5H_9O_2$+H-$CH_3)^+$, 9), 243 ((M-$C_5H_9O_2$+H-$OCH_3)^+$, 2), 231 ((M-I-$CH_3)^+$, 8), 131 ($C_7H_3N_2O^+$, 15), 117 ($C_7H_5N_2^+$, 18), 116 ($C_7H_4N_2^+$, 21), 77 (11), 57 ($C_4H_9^+$, 100), 43 ($C_2H_3O^+$, 12), 41 ($C_2H_3N^+$, 53), 39 ($C_3H_3^+$, 13). Anal. calcd for $C_{13}H_{15}IN_2O_3$ (374.2): C 41.73, H 4.04, N 7.49. Found: C 41.89, H 3.91, N 7.23.

2.4.8. tert-Butyl 3-iodo-2-methyl-1*H*-pyrrolo[2,3-*b*]pyridine-1-carboxylate (1h)

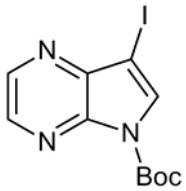


$C_{13}H_{15}IN_2O_2$

358.17

5.58 g (15.6 mmol, 88 % yield over two steps) as a yellow oil (solidified upon storage in refrigerator). Mp 47 °C. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.69 (s, 9 H), 2.69 (s, 3 H), 7.21 (dd, *J* = 7.9 Hz, *J* = 4.7 Hz, 1 H), 7.61 (dd, *J* = 7.9 Hz, *J* = 1.9 Hz, 1 H), 8.43 (dd, *J* = 5.0 Hz, *J* = 1.6 Hz, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 17.9 (CH_3), 28.1 (CH_3), 67.1 (C_{quat}), 84.8 (C_{quat}), 119.1 (CH), 124.4 (C_{quat}), 128.7 (CH), 138.3 (C_{quat}), 145.0 (CH), 148.1 (C_{quat}), 148.8 (C_{quat}). EI + MS (*m/z* (%)): 358 (M^+, 19), 285 ($(M-C_4H_9O)^+$, 4), 258 ($(M-C_5H_9O_2+H)^+$, 100), 158 ($(M-C_4H_9O-I)^+$, 2), 131 ($C_8H_7N_2^+$, 13), 57 ($C_4H_9^+$, 55), 41 ($C_2H_3N^+$, 11). Anal. calcd for $C_{13}H_{15}IN_2O_2$ (358.2): C 43.59, H 4.22, N 7.82. Found: C 43.59, H 4.45, N 7.63.

2.4.9. tert-Butyl 7-iodo-5*H*-pyrrolo[2,3-*b*]pyrazine-5-carboxylate (1i)

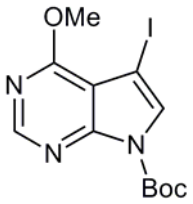


$C_{11}H_{12}IN_3O_2$

345.14

2.53 g (7.33 mmol, 75 % yield over two steps) as a pale yellow solid. Mp 128 °C. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.69 (s, 9 H), 8.12 (s, 1 H), 8.46 (d, *J* = 2.5 Hz, 1 H), 8.60 (d, *J* = 2.5 Hz, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 28.0 (CH_3), 64.2 (C_{quat}), 85.8 (C_{quat}), 134.4 (CH), 139.8 (CH), 141.1 (C_{quat}), 141.3 (CH), 141.8 (C_{quat}), 146.4 (C_{quat}). EI + MS (*m/z* (%)): 345 (M^+, 23), 245 ($(M-C_4H_9+H-CO_2)^+$, 100), 57 ($C_4H_9^+$, 85), 41 (13). Anal. calcd for $C_{11}H_{12}IN_3O_2$ (345.1): C 38.28, H 3.50, N 12.17. Found: C 38.31, H 3.62, N 12.11.

2.4.10. tert-Butyl 5-iodo-4-methoxy-7*H*-pyrrolo[2,3-*d*]pyrimidine-7-carboxylate (1j)

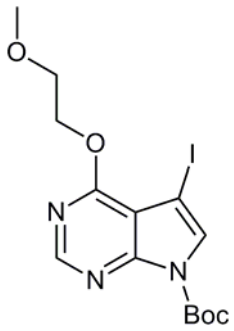


$C_{12}H_{14}IN_3O_3$

375.16

1.12 g (2.98 mmol, 73 % yield over two steps) as a colorless solid. Mp 98-99 °C. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.67 (s, 9 H), 4.15 (s, 3 H), 7.63 (s, 1 H), 8.65 (s, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 27.9 (CH_3), 53.9 (CH_3), 54.9 (C_{quat}), 85.6 (C_{quat}), 109.1 (C_{quat}), 129.4 (CH), 146.2 (C_{quat}), 152.4 (C_{quat}), 153.6 (CH), 163.1 (C_{quat}). EI + MS (*m/z* (%)): 375 (M^+, 7), 276 (9), 275 ((M-$C_5H_9O_2$+H)$^+$, 100), 274 ((M-$C_5H_9O_2$)$^+$, 15), 246 (10), 234 (10), 148 ($C_7H_6N_3O^+$, 7), 118 ($C_6H_4N_3^+$, 8), 57 ($C_4H_9^+$, 50). Anal. calcd for $C_{12}H_{14}IN_3O_3$ (375.2): C 38.42, H 3.76, N 11.20. Found: C 38.46, H 3.85, N 11.32.

2.4.11. *tert*-Butyl 4-(2-methoxyethoxy)-5-iodo-7*H*-pyrrolo[2,3-*d*]pyrimidine-7-carboxylate (1k)

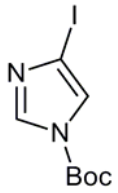


$C_{14}H_{18}IN_3O_4$

419.21

1.55 g (3.70 mmol, 78 % yield over two steps) as a pale yellow oil. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.67 (s, 9 H), 3.49 (s, 3 H), 3.84-3.88 (m, 2 H), 4.67-4.71 (m, 2 H), 7.62 (s, 1 H), 8.62 (s, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 27.9 (CH_3), 55.1 (C_{quat}), 59.3 (CH_3), 66.0 (CH_2), 70.4 (CH_2), 85.6 (C_{quat}), 109.0 (C_{quat}), 129.4 (CH), 146.2 (C_{quat}), 152.5 (C_{quat}), 153.5 (CH), 162.6 (C_{quat}). EI + MS (*m/z* (%)): 419 (M^+, 1), 319 ((M-$C_5H_9O_2$+H)$^+$, 3), 261 ($C_6H_4IN_3O^+$, 6), 88 (13), 70 (13), 61 (16), 45 ($C_2H_5O^+$, 15), 43 (100). Anal. calcd for $C_{14}H_{18}IN_3O_4$ (419.2): C 40.11, H 4.33, N 10.02. Found: C 40.41, H 4.55, N 9.81.

2.4.12. tert-Butyl 4-iodo-1*H*-imidazole-1-carboxylate (1n)

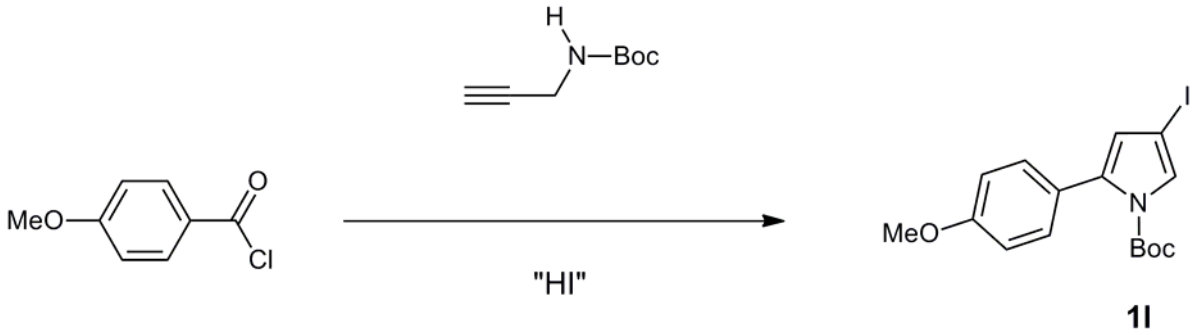


$C_8H_{11}IN_2O_2$

294.09

2.71 g (9.23 mmol, 92 % yield) as a yellow oil. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.62 (s, 9 H), 7.47 (d, *J* = 1.3 Hz, 1 H), 7.95 (d, *J* = 1.3 Hz, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 27.8 (CH_3), 84.3 (C_{quat}), 86.5 (C_{quat}), 122.8 (CH), 138.1 (CH), 145.7 (C_{quat}). EI + MS (*m/z* (%)): 295 (8), 294 (M^+, 62), 238 ($(M-C_4H_9+H)^+$, 12), 221 ($(M-C_4H_9O)^+$, 28), 194 ($(M-C_5H_9O_2+H)^+$, 64), 166 ($(M-I+H)^+$, 18), 59 (10), 58 (19), 57 ($C_4H_9^+$, 100), 41 (64). Anal. calcd for $C_8H_{11}IN_2O_2$ (294.1): C 32.67, H 3.77, N 9.53. Found: C 32.95, H 4.07, N 9.35.

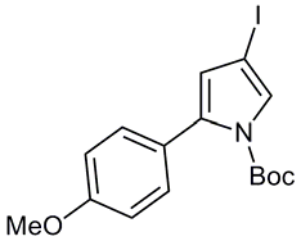
2.5. Preparation of tert-butyl 4-iodo-2-(4-methoxy-phenyl)-1H-pyrrole-1-carboxylate (1l)[3]



1l

$PdCl_2(PPh_3)_2$ (425 mg, 0.60 mmol, 2 mol %) and CuI (233 mg, 1.20 mmol, 4 mol %) were placed under argon atmosphere in a dry screw-cap vessel. Then, 150 mL of dry THF were added and the mixture was degassed with argon. Dry triethylamine (4.16 mL, 30.0 mmol, 1.00 equiv), 4-methoxybenzoyl chloride (5.28 g, 30.0 mmol), and *tert*-butyl prop-2-ynylcarbamate (4.66 g, 30.0 mmol, 1.00 equiv) were successively added to the mixture which was stirred at room temperature for 1 h (monitored by TLC). Then, sodium iodide (22.7 g, 150 mmol, 5.00 equiv), toluene-4-sulfonic acid monohydrate (11.6 g, 60.0 mmol, 2.00 equiv) and 30 ml of *tert*-butanol were successively added to the mixture which was stirred at room temperature for 1 h (monitored by TLC). The reaction mixture was diluted with 300 mL brine, the phases were separated and the aqueous phase was extracted with dichloromethane (3 x 150 mL). The combined organic layers were dried with anhydrous sodium sulfate. After removal of the solvents in vacuo the residue was absorbed onto Celite® and purified chromatographically on silica gel with petroleum ether (boiling range 40-60 °C)/ethyl acetate (PE-EtOAc = 100:1) to give 9.23 g (23.1 mmol, 77 % yield) of the desired product (**1l**) as a colorless solid.

tert-Butyl 4-iodo-2-(4-methoxyphenyl)-1_H_-pyrrole-1-carboxylate (1l)



$C_{16}H_{18}INO_3$

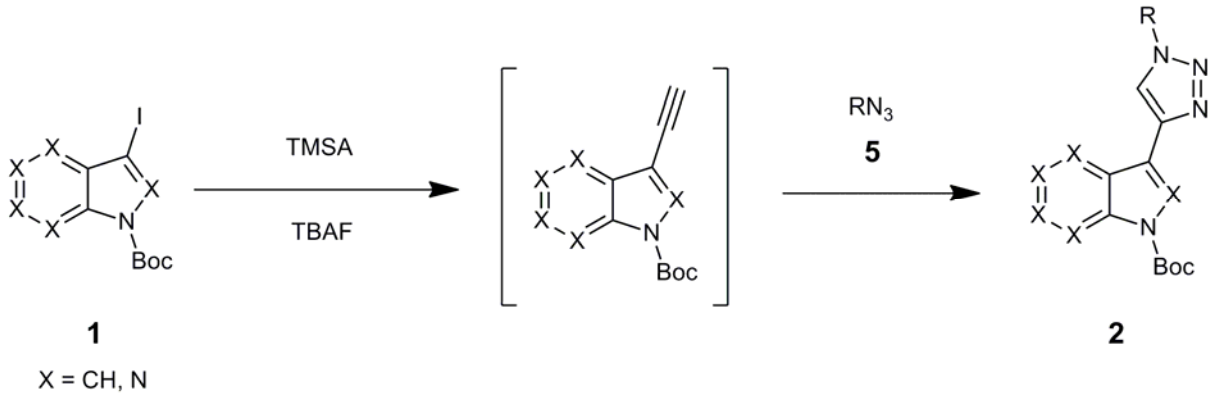
399.22

1.46 g (3.66 mmol, 73 % yield) as a colorless solid. Mp 71-72 °C. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.39 (s, 9 H), 3.82 (s, 3 H), 6.20 (d, J = 1.9 Hz, 1 H), 6.88 (d, J = 8.8 Hz, 1 H), 7.24 (d, J = 8.8 Hz, 1 H), 7.39 (d, J = 1.9 Hz, 1 H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 27.6 (CH_3), 55.3 (CH_3), 64.4 (C_{quat}), 84.2 (C_{quat}), 113.1 (CH), 120.3 (CH), 125.3 (C_{quat}), 126.7 (CH), 130.4 (CH), 136.5 (C_{quat}), 147.9 (C_{quat}), 159.3 (C_{quat}). EI + MS (*m/z* (%)): 399 (M^+, 3), 343 ($(M-C_4H_9+H)^+$, 11), 299 ($(M-C_5H_9O_2+H)^+$, 16), 298 ($(M-C_5H_9O_2)^+$, 13), 171 ($(M-C_5H_9O_2-I)^+$, 6), 156 (12), 128 (11), 57 ($C_4H_9^+$, 100), 41 (34). IR (KBr): $\tilde{\nu}$ 3145 (m) cm^{-1}, 2986 (m), 2934 (w), 2832 (w), 1734 (s), 1609 (m), 1576 (w), 1557 (w), 1511 (s), 1476 (m), 1460 (m), 1435 (w), 1370 (s), 1337 (s), 1293 (s), 1251 (s), 1180 (s), 1151 (s), 1108 (m), 1032 (s), 985 (m), 904 (m), 847 (s), 833 (m), 808 (s), 771 (m), 675 (w), 629 (w), 615 (w), 594 (m), 528 (w), 511 (w). Anal. calcd for $C_{16}H_{18}INO_3$ (399.2): C 48.14, H 4.54, N 3.51. Found: C 48.36, H 4.37, N 3.34.

3 Multicomponent Syntheses of Triazolyl Substituted *N*-Boc protected *NH*-Heterocycles 2a-s

3.1. Three-component Sonogashira coupling – TMS-deprotection – CuAAC sequence

3.1.1. General procedure for the preparation of compounds 2a-o



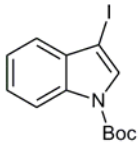
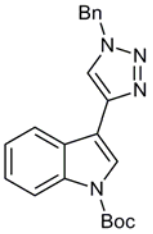
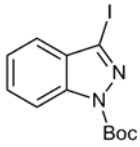
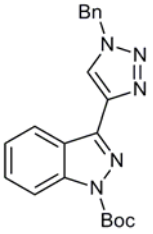
$PdCl_2(PPh_3)_2$ (14 mg, 0.02 mmol, 2 mol %) and CuI (8 mg, 0.04 mmol, 4 mol %) were placed in a dry screw-cap Schlenk vessel with septum. Then, 1.00 mmol of *N*-Boc iodo *NH*-heterocycle **1** was added in 5 mL of dry tetrahydrofuran under argon atmosphere and the reaction mixture was degassed with argon. After that, trimethylsilylacetylene (0.21 mL, 1.50 mmol, 1.50 equiv) and dry triethylamine (0.28 mL, 2.00 mmol, 2.00 equiv) were added and the mixture was stirred at room temperature (water bath) until the complete consumption of the starting material (monitored by TLC). Then, 1 M solution of tetrabutylammonium fluoride in tetrahydrofuran (1.50 mL, 1.50 mmol, 1.50 equiv) was added dropwise and the mixture was stirred at room temperature for 0.5 h until the deprotection was complete (monitored by TLC). After that, benzyl azide (**5a**) (136 mg, 1.00 mmol, 1.00 equiv) in 1 mL of dry methanol* was added and the mixture was stirred at room temperature until the complete conversion to the product (monitored by TLC). After removal of the solvents in vacuo the residue was absorbed onto Celite® and purified chromatographically on silica gel with petroleum ether (boiling range 40-60 °C)/ethyl

acetate to give the *N*-Boc protected triazoles **2**. The obtained compounds were not characterized but directly deprotected in the next step.

* For the synthesis of compound **2g** 2 mL of phenyl azide solution (~ 0.5 *M* in TBME) (**5b**) (1.00 mmol, 1.00 equiv) were added, followed by the addition of 1 mL of dry methanol.

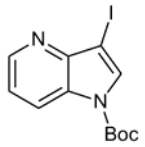
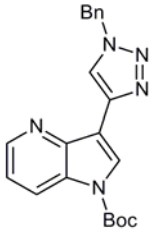
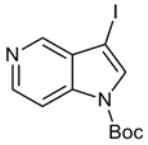
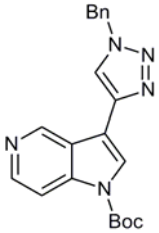
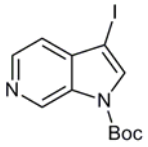
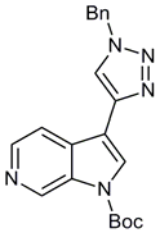
The experimental details are depicted in ***Table 1***.

Table 1. Experimental details of the three-component *Sonogashira*-CuAAC sequence for the synthesis of *N*-Boc protected (aza)indolyl triazoles **2a**-**b**.

Entry	*N*-Boc iodo *NH*-heterocycle **1**	Reaction time[a] 1st step 2nd step	*N*-Boc protected (aza)indolyl triazole **2**	Chromatographic purification (eluent) R_f (eluent)
1	343 mg (1.00 mmol)  **1a**	1 h 4 d	Beige-yellow solid 280 mg (0.75 mmol, 75 %)  **2a**	PE-EtOAc = 5:1
2	688 mg (2.00 mmol)  **1b**	2 h 24 h	Pale beige solid 538 mg (1.43 mmol, 72 %)  **2b**	PE-EtOAc = 5:1 R_f (PE-EtOAc = 5:1) = 0.13

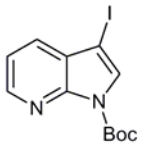
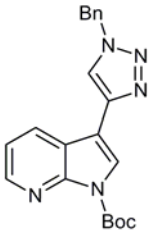
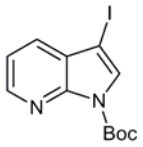
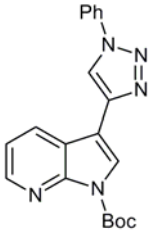
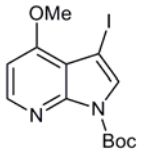
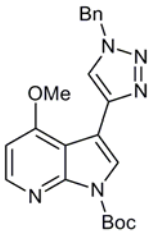
[a] The reaction times are not optimized and might be shorter than indicated.

Table 1 (continuation). Experimental details of the three-component *Sonogashira*-CuAAC sequence for the synthesis of *N*-Boc protected (aza)indolyl triazoles **2c**-**e**.

Entry	*N*-Boc iodo *NH*-heterocycle **1**	Reaction time[a] 1st step 2nd step	*N*-Boc protected (aza)indolyl triazole **2**	Chromatographic purification (eluent)
3	344 mg (1.00 mmol)  **1c**	1 h 3 d	Pale yellow solid 230 mg (0.61 mmol, 61 %)  **2c**	PE-EtOAc = 3:1
4	344 mg (1.00 mmol)  **1d**	1 h 24 h	Colorless solid 207 mg (0.55 mmol, 55 %)  **2d**	PE-EtOAc = 1:1
5	344 mg (1.00 mmol)  **1e**	1 h 24 h	Pale yellow oil 218 mg (0.58 mmol, 58 %)  **2e**	PE-EtOAc = 1:1

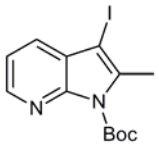
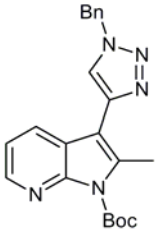
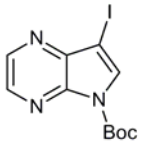
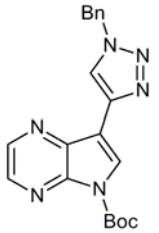
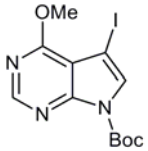
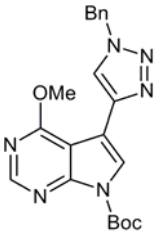
[a] The reaction times are not optimized and might be shorter than indicated.

Table 1 (continuation). Experimental details of the three-component *Sonogashira*-CuAAC sequence for the synthesis of *N*-Boc protected (aza)indolyl triazoles **2f**-**h**.

Entry	*N*-Boc iodo *NH*-heterocycle **1**	Reaction time[a] 1st step 2nd step	*N*-Boc protected (aza)indolyl triazole **2**	Chromatographic purification (eluent) R_f (eluent)
6	1.72 g (5.00 mmol)  **1f**	1 h 40 h	Yellow foam 1.56 g (4.15 mmol, 83 %)[b]  **2f**	PE-EtOAc = 2:1 R_f (PE-EtOAc = 2:1): 0.20
7	344 mg (1.00 mmol)  **1f**	1 h 66 h	Yellow foam 254 mg (0.70 mmol, 70 %)  **2g**	PE-EtOAc = 3:1
8	374 mg (1.00 mmol)  **1g**	1 h 64 h	Pale yellow solid 219 mg (0.54 mmol, 54 %)  **2h**	PE-EtOAc = 1:1 → 1:2

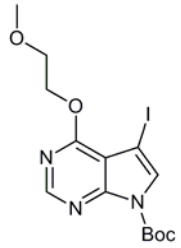
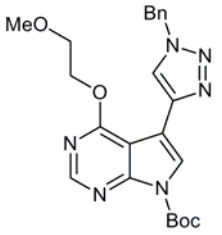
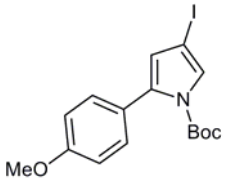
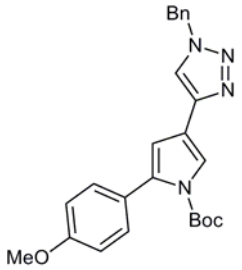
[a] The reaction times are not optimized and might be shorter than indicated.
[b] On a 1.00 mmol scale, 295 mg (0.79 mmol, 79 % yield) of a yellow foam were obtained.

Table 1 (continuation). Experimental details of the three-component *Sonogashira*-CuAAC sequence for the synthesis of *N*-Boc protected (aza)indolyl triazoles **2i**-**k**.

Entry	*N*-Boc iodo *NH*-heterocycle **1**	Reaction time[a] 1st step 2nd step	*N*-Boc protected (aza)indolyl triazole **2**	Chromatographic purification (eluent)
9	716 mg (2.00 mmol)  **1h**	23 h 119 h	Pale yellow solid 462 mg (1.19 mmol, 59 %)  **2i**	PE-EtOAc = 3:1
10	345 mg (1.00 mmol)  **1i**	1 h 48 h	Colorless solid 211 mg (0.56 mmol, 56 %)  **2j**	PE-EtOAc = 2:1
11	375 mg (1.00 mmol)  **1j**	1 h 72 h	Yellow solid 297 mg (0.73 mmol, 73 %)  **2k**	PE-EtOAc = 1:1

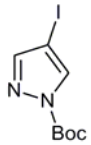
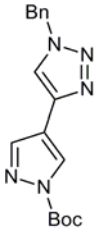
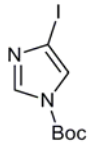
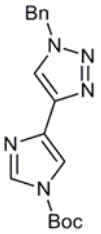
[a] The reaction times are not optimized and might be shorter than indicated.

Table 1 (continuation). Experimental details of the three-component *Sonogashira*-CuAAC sequence for the synthesis of *N*-Boc protected (aza)indolyl triazole **2l** and pyrrolyl triazole **2m**.

Entry	*N*-Boc iodo *NH*-heterocycle **1**	Reaction time[a] 1st step 2nd step	*N*-Boc protected (aza)indolyl or pyrrolyl triazole **2**	Chromatographic purification (eluent)
12	720 mg (1.72 mmol)  **1k**	1 h 87 h	Pale yellow foam 341 mg (0.97 mmol, 57 %)  **2l**	PE-EtOAc = 1:1
13	399 mg (1.00 mmol)  **1l**	2 h 115 h	Yellow oil 224 mg (0.52 mmol, 52 %)  **2m**	PE-EtOAc = 3:1

[a] The reaction times are not optimized and might be shorter than indicated.

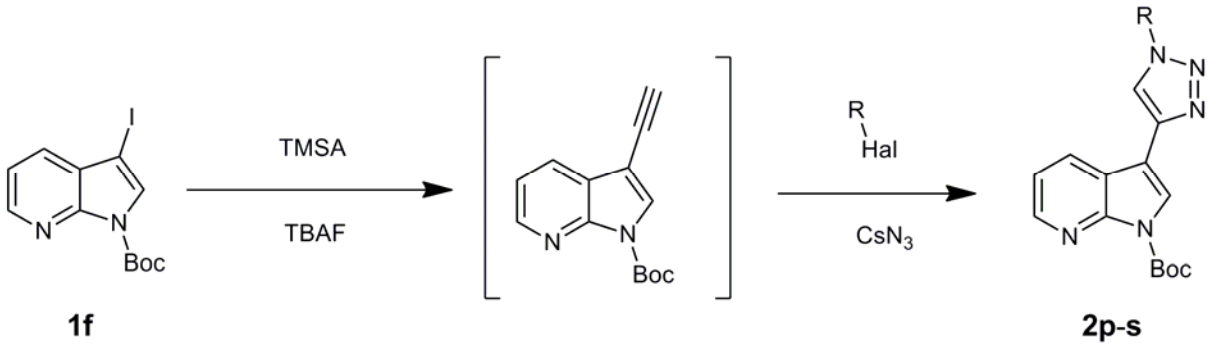
Table 1 (continuation). Experimental details of the three-component *Sonogashira*-CuAAC sequence for the synthesis of *N*-Boc protected azolyl triazoles **2n**-**o**.

Entry	*N*-Boc iodo *NH*-heterocycle **1**	Reaction time[a] 1st step 2nd step	*N*-Boc protected azolyl triazole **2**	Chromatographic purification (eluent)
14	294 mg (1.00 mmol) *tert*-Butyl 4-iodo-1*H*-pyrazole-1-carboxylate (*ABCR*)  **1m**	3 h 63 h	Yellow-orange oil 208 mg (0.64 mmol, 64 %)  **2n**	PE-EtOAc = 1:1
15	294 mg (1.00 mmol)  **1n**	15 d 23 h	Yellow oil 99 mg (0.30 mmol, 30 %)  **2o**	PE-EtOAc = 1:1

[a] The reaction times are not optimized and might be shorter than indicated.

3.2. Four-component Sonogashira coupling – TMS-deprotection – Azide-Halide exchange – CuAAC sequence

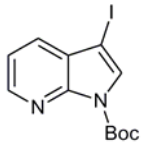
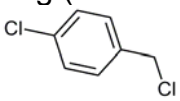
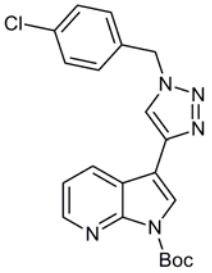
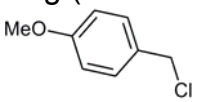
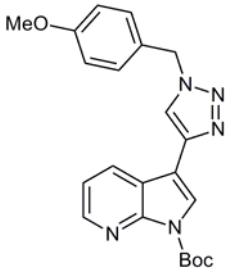
3.2.1. General procedure for the preparation of compounds 2p-s



$PdCl_2(PPh_3)_2$ (14 mg, 0.02 mmol, 2 mol %) and CuI (8 mg, 0.04 mmol, 4 mol %) were placed in a dry screw-cap Schlenk vessel with septum. Then, *tert*-butyl 3-iodo-1*H*-pyrrolo[2,3-*b*]pyridine-1-carboxylate (**1f**) (344 mg, 1.00 mmol) was added in 5 mL of dry tetrahydrofuran under argon atmosphere and the reaction mixture was degassed with argon. After that, trimethylsilylacetylene (0.21 mL, 1.50 mmol, 1.50 equiv) and dry triethylamine (0.28 mL, 2.00 mmol, 2.00 equiv) were added and the mixture was stirred at room temperature (water bath) until the complete consumption of the starting material (monitored by TLC). Then, 1 M solution of tetrabutylammonium fluoride in tetrahydrofuran (1.50 mL, 1.50 mmol, 1.50 equiv) was added dropwise and the mixture was stirred at room temperature for 0.5 h until the deprotection was complete (monitored by TLC). After that, cesium azide (175 mg, 1.00 mmol, 1.00 equiv) and an organic halide (1.00 mmol, 1.00 equiv) in 1 mL of dry methanol were added and the mixture was stirred at room temperature until the complete conversion to the product (monitored by TLC). After removal of the solvents in vacuo the residue was absorbed onto Celite® and purified chromatographically on silica gel with petroleum ether (boiling range 40-60 °C)/ethyl acetate to give the *N*-Boc protected 7-azaindolyl triazoles **2p**-**s**. The obtained compounds were not characterized but used as obtained in the subsequent deprotection step.

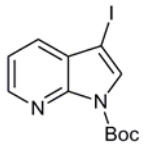
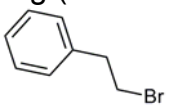
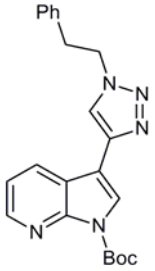
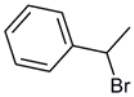
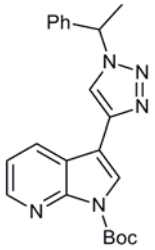
The experimental details are depicted in ***Table 3***.

Table 3. Experimental details of the four-component *Sonogashira* coupling – TMS-deprotection – azide-halide exchange – CuAAC sequence for the synthesis of indolyl triazoles **2p**-**s**.

Entry	*N*-Boc 3-iodo 7-azaindole **1f** In situ generated azide **5**	Reaction time[a] 1st step 2nd step	*N*-Boc protected 7-azaindolyl triazole **2**	Chromatographic purification (eluent)
1	688 mg (2.00 mmol)  **1f** 350 mg (2.00 mmol) CsN_3 (*Aldrich*) 322 mg (2.00 mmol)  (*Merck*) **5c**	1 h 51 h	Pale yellow solid 444 mg (1.08 mmol, 54 %)  **2p**	PE-EtOAc = 2:1
2	344 mg (1.00 mmol) **1f** 175 mg (1.00 mmol) CsN_3 163 mg (1.00 mmol)  (*ABCR*) **5d**	1 h 72 h	Yellow foam 295 mg (0.73 mmol, 73 %)  **2q**	PE-EtOAc = 2:1

[a] The reaction times are not optimized and might be shorter than indicated.

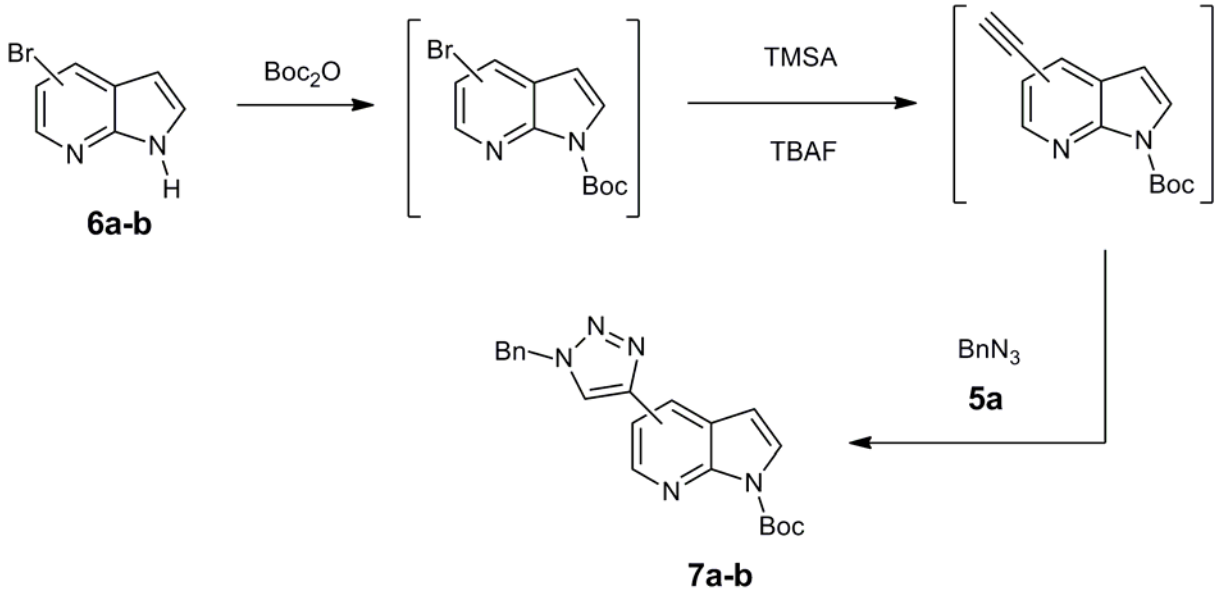
Table 3. Experimental details of the three-component *Sonogashira*-CuAAC sequence for the synthesis of indolyl triazoles **2p**-**s**.

Entry	*N*-Boc 3-iodo 7-azaindole **1** In situ generated azide **5**	Reaction time[a] 1st step 2nd step	*N*-Boc protected 7-azaindolyl triazole **2**	Chromatographic purification (eluent)
3	344 mg (1.00 mmol)  **1f** 175 mg (1.00 mmol) CsN_3 (*Aldrich*) 189 mg (1.00 mmol)  (*Merck*) **5e**	1 h 111 h	Yellow oil 269 mg (0.69 mmol, 69 %)  **2r**	PE-EtOAc = 2:1
4	344 mg (1.00 mmol) **1f** 175 mg (1.00 mmol) CsN_3 (*Aldrich*) 191 mg (1.00 mmol)  (*ABCR*) **5f**	1 h 64 h	Yellow oil 250 mg (0.64 mmol, 64 %)  **2s**	PE-EtOAc = 2:1

[a] The reaction times are not optimized and might be shorter than indicated.

3.3. Four-component Boc-protection – Sonogashira coupling – TMS-deprotection – CuAAC sequence

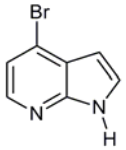
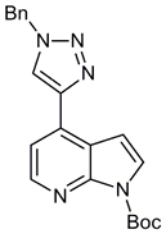
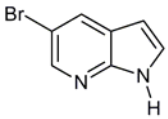
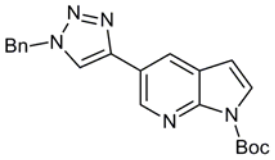
3.3.1. General procedure for the preparation of compounds 7a-b



1.00 mmol of a bromo-7-azaindole **6** was placed under argon atmosphere in a dry screw-cap Schlenk vessel with septum. Then, di-*tert*-butyl dicarbonate (338 mg, 1.50 mmol, 1.50 equiv) in 1 mL of dry 1,4-dioxane and 4-dimethylaminopyridine (12 mg, 0.10 mmol, 10 mol %) were added under argon atmosphere and the reaction mixture was stirred at room temperature (water bath) for 15 min until the complete consumption of the starting material (evolution of a gas ceased, monitored by TLC). After that, 1 mL of dry methanol was added and the mixture was degassed with argon. Then, $PdCl_2(PhCN)_2$ (8 mg, 0.02 mmol, 2 mol %), $[^tBu_3PH]BF_4$ (12 mg, 0.04 mmol, 4 mol %), CuI (8 mg, 0.04 mmol, 4 mol %), trimethylsilylacetylene (0.21 mL, 1.50 mmol, 1.50 equiv), and dry triethylamine (0.28 mL, 2.00 mmol, 2.00 equiv) were added subsequently and the mixture was stirred at room temperature until the complete consumption of the starting material (monitored by TLC). Then, 1 M solution of tetrabutylammonium fluoride in tetrahydrofuran (1.50 mL, 1.50 mmol, 1.50 equiv) was added dropwise and the mixture was stirred at room temperature for 0.5 h until the deprotection was complete (monitored by TLC). After that, benzyl azide (**5a**) (136 mg, 1.00 mmol, 1.00 equiv) in 1 mL of dry methanol was added and the mixture was stirred at room temperature until the complete conversion to the product (monitored by TLC). After removal of the solvents in vacuo the residue was absorbed onto Celite® and purified chromatographically on silica gel with petroleum ether (boiling range 40-60 °C)/ethyl acetate to give the *N*-Boc protected 7-azaindolyl triazole **7**. The obtained compound was not characterized but used as obtained in the subsequent deprotection step.

The experimental details are depicted in ***Table 4***.

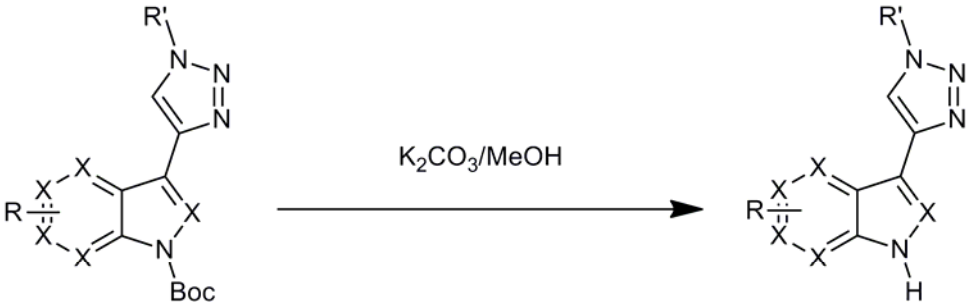
***Table 4*.** Experimental details for the four-component Boc-protection – *Sonogashira* coupling – TMS-deprotection – CuAAC sequence for the synthesis of *N*-Boc protected 7-azaindolyl triazoles **7a**-**b**.

Entry	Bromo-7-azaindole **6**	Reaction time[a] 2nd step[b] 3rd step[c]	*N*-Boc protected 7-azaindolyl triazole **7** (isolated yield %)	Chromatographic purification (eluent)
1	205 mg (1.00 mmol)  (4-Bromo-7-azaindole) (*Aldrich*) **6a**	1 h 18 h	Yellow oil 311 mg (0.83 mmol, 83 %)  **7a**	PE-EtOAc = 1:1
2	203 mg (1.00 mmol)  (5-Bromo-7-azaindole) (*Aldrich*) **6b**	5 h 4 d	Yellow oil 373 mg (0.99 mmol, 99 %)  **7b**	PE-EtOAc = 2:1

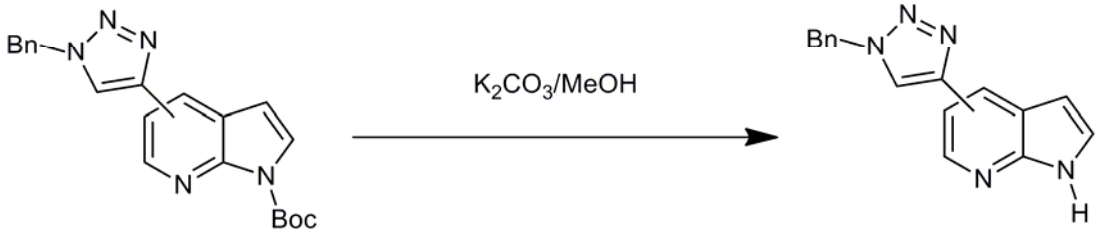
[a] The reaction times are not optimized and might be shorter than indicated.
[b] 2nd step: Sonogashira coupling with TMSA.
[c] 3rd step: CuAAC with benzyl azide (**5a**).

4. Deprotection of *N*-Boc Protected Triazolyl *NH*-Heterocycles

4.1. General procedure for the preparation of compounds 8a-s and 9a-b



2a-s **8a-s**



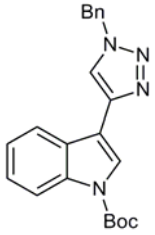
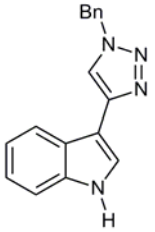
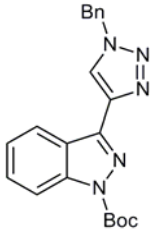
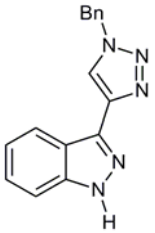
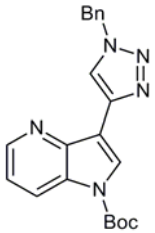
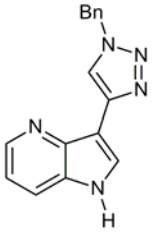
7a-b **9a-b**

N-Boc protected triazolyl heterocycle **2** or **7** was placed in methanol (c = 0.2 M). Then, 2.50 equiv of potassium carbonate were added and the mixture was stirred at room temperature (water bath) or 50 °C (for compounds **2a** and **2i**, preheated oil bath) for 1 h* (monitored by TLC). Frequently, a precipitate was formed. The mixture was adsorbed on Celite® and purified chromatographically on silica gel with dichloromethane-methanol-aqueous ammonia. After drying in vacuo at 70 °C overnight, analytically pure triazoles **8** or **9** were obtained. The products can be further purified by suspension in dichloromethane and sonication in ultrasound bath for 0.5-1 h, filtration and drying in vacuo at 70 °C overnight.

* 5 h for compound **2m**.

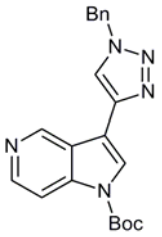
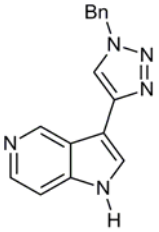
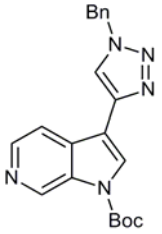
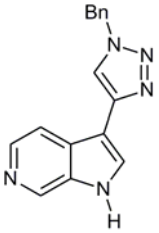
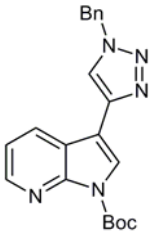
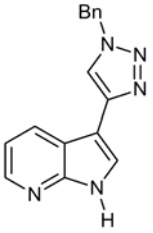
The experimental details are given in ***Table 5***, ***Table 6***, and ***Table 7***.

Table 5. Experimental details for the deprotection of *N*-Boc (aza)indolyl triazoles **8a-c**.

Entry	*N*-Boc protected (aza)indolyl triazole **2**	(Aza)indolyl triazole **8** (isolated yield %)	Chromatographic purification (eluent) UV purity
1	280 mg (0.75 mmol)  **2a**	Pale yellow solid[a] 147 mg (0.54 mmol, 72 %) Total yield: 54 %  **8a**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 HT-LC-MS: 100 %
2	404 mg (1.08 mmol)  **2b**	Colorless solid 264 mg (0.96 mmol, 89 %) Total yield: 64 %  **8b**	$DCM-MeOH-NH_3$ = 100:1:1 HT-LC-MS: 100 %[b]
3	230 mg (0.61 mmol)  **2c**	Colorless solid 137 mg (0.50 mmol, 81 %) Total yield: 50 %  **8c**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1 HT-LC-MS: 100 %

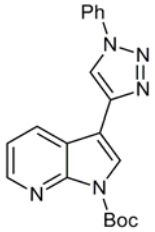
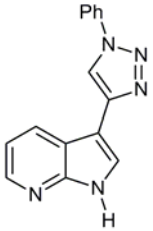
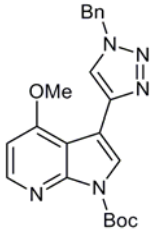
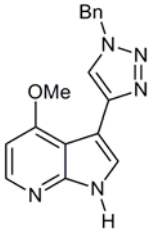
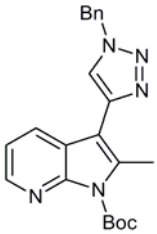
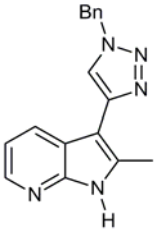
[a] Deprotection was performed at 50 °C for 1 h.
[b] Additionally purified by suspension in DCM and sonication in ultrasound bath.

Table 5 (continuation). Experimental details for the deprotection of *N*-Boc (aza)indolyl triazoles **8d**-**f**.

Entry	*N*-Boc protected (aza)indolyl triazole **2**	(Aza)indolyl triazole **8** (isolated yield %)	Chromatographic purification (eluent) UV purity
4	149 mg (0.40 mmol)  **2d**	Colorless solid 95 mg (0.35 mmol, 86 %) Total yield: 48 %  **8d**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1 → 100:6:1 → 100:7:1 HT-LC-MS: 100 %[a]
5	149 mg (0.40 mmol)  **2e**	Pale yellow solid 93 mg (0.34 mmol, 85 %) Total yield: 50 %  **8e**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1 → 100:6:1 → 100:7:1 HT-LC-MS: 99.9 %[a]
6	1.56 g (4.15 mmol)  **2f**	Colorless solid 930 mg (3.38 mmol, 81 %) Total yield: 67 %[b]  **8f**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 HT-LC-MS: 100 %[a]

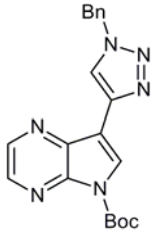
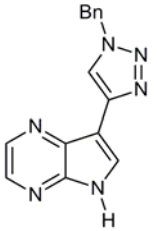
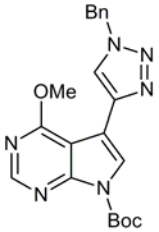
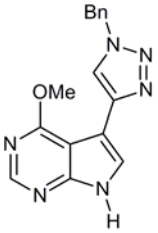
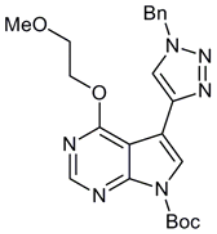
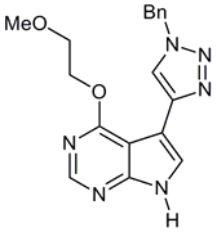
[a] Additionally purified by suspension in DCM and sonication in ultrasound bath.
[b] On a 1.00 mmol scale, 179 mg (0.65 mmol, 65 % yield over two steps) were obtained as a colorless solid.

Table 5 (continuation). Experimental details for the deprotection of *N*-Boc (aza)indolyl triazoles **8g**-**i**.

Entry	*N*-Boc protected (aza)indolyl triazole **2**	(Aza)indolyl triazole **8** (isolated yield %)	Chromatographic purification (eluent) UV purity
7	254 mg (0.70 mmol)  **2g**	Yellow solid 143 mg (0.55 mmol, 78 %) Total yield: 55 %  **8g**	DCM-MeOH-NH_3 = 100:1:1 → 100:2:1 → 100:3:1 HT-LC-MS: 100 %
8	162 mg (0.40 mmol)  **2h**	Yellow solid 109 mg (0.36 mmol, 89 %) Total yield: 48 %  **8h**	DCM-MeOH-NH_3 = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1 → 100:6:1 HT-LC-MS: 100 %[a]
9	462 mg (1.19 mmol)  **2i**	Colorless solid[b] 300 mg (1.04 mmol, 87 %) Total yield: 52 %  **8i**	DCM-MeOH-NH_3 = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1 HT-LC-MS: 100 %

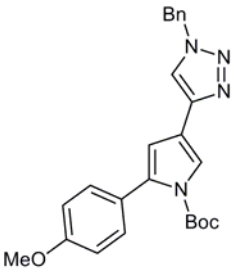
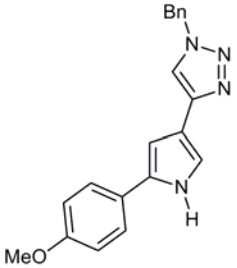
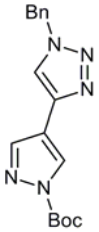
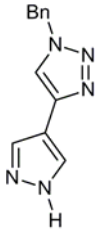
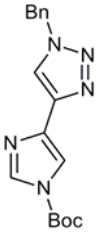
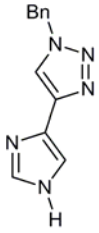
[a] Additionally purified by suspension in DCM and sonication in ultrasound bath.
[b] Deprotection was performed at 50 °C for 1 h.

Table 5 (continuation). Experimental details for the deprotection of *N*-Boc (aza)indolyl triazoles **8j**-**l**.

Entry	*N*-Boc protected (aza)indolyl triazole **2**	(Aza)ndolyl triazole **8** (isolated yield %)	Chromatographic purification (eluent) UV purity
10	152 mg (0.40 mmol)  **2j**	Colorless solid 93 mg (0.34 mmol, 83 %) Total yield: 47 %  **8j**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1→ 100:6:1 HT-LC-MS: 100 %
11	297 mg (0.73 mmol)  **2k**	Colorless solid 165 mg (0.54 mmol, 74 %) Total yield: 54 %  **8k**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 HT-LC-MS: 100 %
12	197 mg (0.56 mmol)  **2l**	Colorless solid 141 mg (0.40 mmol, 72 %) Total yield: 41 %  **8l**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1 HT-LC-MS: 100 %[a]

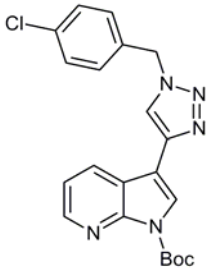
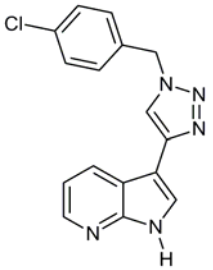
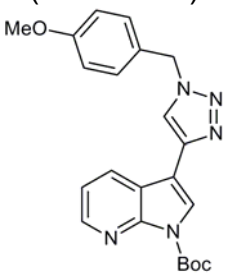
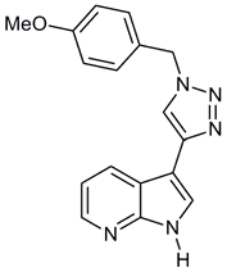
[a] Additionally purified by suspension in DCM and sonication in ultrasound bath.

Table 5 (continuation). Experimental details for the deprotection of *N*-Boc azolyl triazoles **8m**-**o**.

Entry	*N*-Boc protected azolyl triazole **2**	Azolyl triazole **8** (isolated yield %)	Chromatographic purification (eluent) UV purity
13	224 mg (0.52 mmol)  **2m**	Pale yellow solid[a] 147 mg (0.44 mmol, 85 %) Total yield: 44 %  **8m**	$DCM-MeOH-NH_3$ = 100:1:1 HT-LC-MS: 100 %
14	208 mg (0.64 mmol)  **2n**	Colorless solid 86 mg (0.38 mmol, 60 %) Total yield: 38 %  **8n**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1 → 100:6:1 → 100:7:1 HT-LC-MS: 100 %
15	99 mg (0.30 mmol)  **2o**	Colorless solid 46 mg (0.20 mmol, 68 %) Total yield: 20 %  **8o**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1 → 100:6:1 → 100:7:1 HT-LC-MS: 100 %

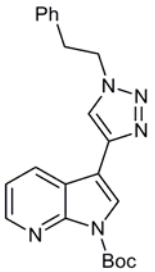
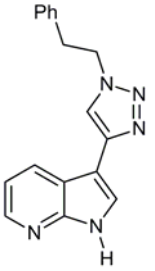
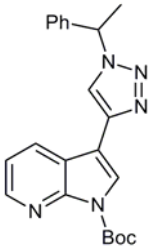
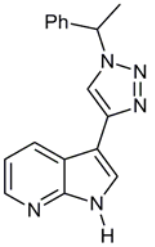
[a] Deprotection was performed at room temperature for 5 h.

Table 6. Experimental details for the deprotection of *N*-Boc 7-azaindolyl triazoles **8p-q**.

Entry	*N*-Boc protected 7-azaindolyl triazole **2**	7-Azaindolyl triazole **8** (isolated yield %)	Chromatographic purification (eluent) UV purity
16	347 mg (0.85 mmol)  **2p**	Colorless solid 218 mg (0.70 mmol, 83 %) Total yield: 45 %  **8p**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1 → 100:6:1 → 100:7:1 HT-LC-MS: 100 %[a]
17	295 mg (0.73 mmol)  **2q**	Colorless solid 179 mg (0.58 mmol, 80 %) Total yield: 58 %  **8q**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 HT-LC-MS: 100 %[a]

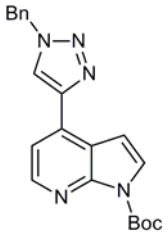
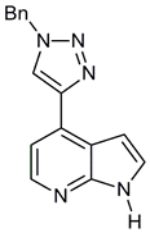
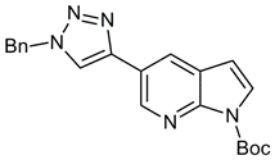
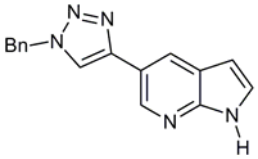
[a] Additionally purified by suspension in DCM and sonication in ultrasound bath.

Table 6 (continuation). Experimental details for the deprotection of *N*-Boc 7-azaindolyl triazoles **8r**-**s**.

Entry	*N*-Boc protected 7-azaindolyl triazole **2**	7-Azaindolyl triazole **8** (isolated yield %)	Chromatographic purification (eluent) UV purity
18	269 mg (0.69 mmol)  **2r**	Colorless solid 179 mg (0.62 mmol, 90 %) Total yield: 62 %  **8r**	DCM-MeOH-NH_3 = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1 → 100:6:1 → 100:7:1 HT-LC-MS: 100 %[a]
19	250 mg (0.64 mmol)  **2s**	Pale yellow solid 160 mg (0.55 mmol, 86 %) Total yield: 55 %  **8s**	DCM-MeOH-NH_3 = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 HT-LC-MS: 100 %[a]

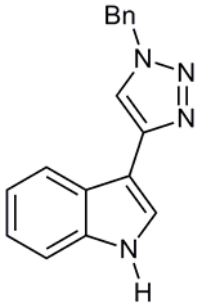
[a] Additionally purified by suspension in DCM and sonication in ultrasound bath.

Table 7. Experimental details for the Boc-deprotection of 7-azaindolyl triazoles **9a**-**b**.

Entry	*N*-Boc protected 7-azaindolyl triazole **7**	7-Azaindolyl triazole **9** (isolated yield %)	Chromatographic purification (eluent) UV purity
20	311 mg (0.83 mmol)  **7a**	Colorless solid 207 mg (0.75 mmol, 91 %) Total yield: 75 %  **9a**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 → 100:5:1 HT-LC-MS: 100 %
21	373 mg (0.99 mmol)  **7b**	Colorless solid 182 mg (0.66 mmol, 66 %) Total yield: 66 %  **9b**	$DCM-MeOH-NH_3$ = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 HT-LC-MS: 100 %

4.2. Spectroscopic data of compounds 8a-s and 9a-b

4.2.1. 3-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-1*H*-indole (8a)

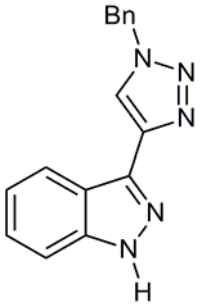


$C_{17}H_{14}N_4$

274.32

147 mg (0.54 mmol, 54 % yield over two steps) as a pale yellow solid. Mp 171 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.64 (s, 2 H), 7.08-7.12 (m, 1 H), 7.13-7.18 (m, 1 H), 7.31-7.36 (m, 1 H), 7.36-7.41 (m, 4 H), 7.42-7.45 (m, 1 H), 7.79 (d, *J* = 2.5 Hz, 1 H), 8.03 (d, *J* = 7.9 Hz, 1 H), 8.49 (s, 1 H), 11.3 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.8 (CH_2), 106.1 (C_{quat}), 111.8 (CH), 119.5 (CH), 119.6 (CH), 119.9 (CH), 121.6 (CH), 123.1 (CH), 124.6 (C_{quat}), 127.9 (CH), 128.1 (CH), 128.8 (CH), 136.3 (C_{quat}), 136.3 (C_{quat}), 142.9 (C_{quat}). EI + MS (*m/z* (%)): 275 (9), 274 (M^+, 44), 246 (47), 245 (100), 219 (11), 218 (50), 217 (16), 169 ($C_{10}H_7N_3^+$, 31), 155 (46), 129 (10), 128 (43), 127 (10), 117 (16), 115 (12), 101 (26), 91 ($C_7H_7^+$, 43), 77 ($C_6H_5^+$, 14), 65 ($C_5H_5^+$, 12). IR (KBr): $\tilde{\nu}$ 3397 (s) cm^{-1}, 1624 (w), 1601 (w), 1497 (w), 1456 (m), 1337 (w), 1221 (m), 1099 (w), 1053 (w), 939 (w), 776 (w), 749 (m), 727 (m), 586 (w), 522 (w). Anal. calcd for $C_{17}H_{14}N_4$ (274.3): C 74.43, H 5.14, N 20.42. Found: C 74.31, H 4.91, N 20.36.

4.2.2. 3-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-1*H*-indazole (8b)

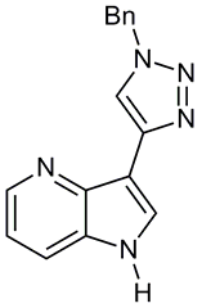


$C_{16}H_{13}N_5$

275.31

264 mg (0.96 mmol, 64 % yield over two steps) as a colorless solid. Further purified by suspension in DCM and sonication in ultrasound bath. Mp 164 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.70 (s, 2 H), 7.19-7.23 (m, 1 H), 7.31-7.43 (m, 6 H), 7.55-7.59 (m, 1 H), 8.29 (d, *J* = 8.2 Hz, 1 H), 8.69 (d, *J* = 0.9 Hz, 1 H), 13.24 (s, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.9 (CH_2), 110.2 (CH), 120.2 (C_{quat}), 120.9 (CH), 121.4 (CH), 121.7 (CH), 126.4 (CH), 127.9 (CH), 128.1 (CH), 128.7 (CH), 136.0 (C_{quat}), 136.1 (C_{quat}), 140.9 (C_{quat}), 142.2 (C_{quat}). EI + MS (*m/z* (%)): 275 (M^+, 79), 246 ($(M\text{-}HN_2)^+$, 84), 219 (16), 156 ($C_9H_6N_3^+$, 79), 102 (21), 91 ($C_7H_7^+$, 100), 65 ($C_5H_5^+$, 20). IR (KBr): $\tilde{\nu}$ 3181 (s) cm^{-1}, 1624 (w), 1597 (w), 1497 (w), 1478 (w), 1457 (m), 1431 (w), 1348 (m), 1299 (w), 1241 (m), 1228 (w), 1217 (w), 1152 (w), 1133 (w), 1098 (w), 1062 (m), 1046 (w), 1003 (w), 965 (w), 904 (w), 819 (w), 773 (w), 750 (s), 715 (s), 584 (w). Anal. calcd for $C_{16}H_{13}N_5$ (275.3): C 69.80, H 4.76, N 25.44. Found: C 69.68, H 4.63, N 25.50.

4.2.3. 3-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-1*H*-pyrrolo[3,2-*b*]pyridine (8c)

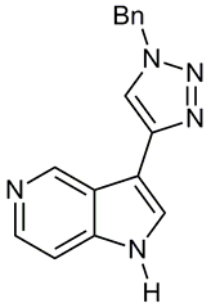


$C_{16}H_{13}N_5$

275.31

137 mg (0.50 mmol, 50 % yield over two steps) as a colorless solid. Mp 246 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.69 (s, 2 H), 7.18 (dd, *J* = 8.2 Hz, *J* = 4.7 Hz, 1 H), 7.30-7.36 (m, 1 H), 7.36-7.41 (m, 4 H), 7.83 (dd, *J* = 8.2 Hz, *J* = 1.3 Hz, 1 H), 8.1 (br, 1 H), 8.40 (dd, *J* = 4.7 Hz, *J* = 1.3 Hz, 1 H), 8.61 (s, 1 H), 11.6 (br, 1 H, N<u>H</u>). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.7 (CH_2), 106.5 (C_{quat}), 116.9 (CH), 119.1 (CH), 120.5 (CH), 125.6 (CH), 128.0 (CH), 128.1 (CH), 128.8 (CH), 129.0 (C_{quat}), 136.4 (C_{quat}), 140.9 (C_{quat}), 142.5 (C_{quat}), 142.8 (CH). EI + MS (*m/z* (%)): 275 (M^+, 21), 247 (20), 246 ((M-HN_2)$^+$, 100), 219 (19), 156 ($C_9H_6N_3^+$, 76), 149 (23), 143 (20), 129 (26), 102 (16), 97 (11), 91 ($C_7H_7^+$, 46), 89 (13), 85 (11), 84 (14), 83 (11), 77 ($C_6H_5^+$, 15), 71 (14), 69 (10), 65 ($C_5H_5^+$, 11), 57 (18), 55 (11), 43 (13). IR (KBr): $\tilde{\nu}$ 3163 (s) cm^{-1}, 3047 (m), 1628 (s), 1561 (w), 1497 (w), 1457 (w), 1413 (s), 1362 (m), 1335 (w), 1314 (w), 1277 (w), 1221 (w), 1200 (w), 1123 (w), 1106 (w), 1085 (w), 1051 (s), 943 (w), 889 (w), 776 (s), 718 (s), 697 (w), 613 (w), 580 (w), 508 (w). Anal. calcd for $C_{16}H_{13}N_5$ (275.3): C 69.80, H 4.76, N 25.44. Found: C 69.85, H 4.94, N 25.34.

4.2.4. 3-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-1*H*-pyrrolo[3,2-*c*]pyridine (8d)

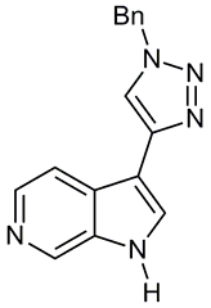


$C_{16}H_{13}N_5$

275.31

95 mg (0.35 mmol, 48 % yield over two steps) as a colorless solid. Mp 195 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.66 (s, 2 H), 7.31-7.37 (m, 1 H), 7.37-7.41 (m, 4 H), 7.43 (d, *J* = 5.7 Hz, *J* = 0.6 Hz, 1 H), 7.89 (s, 1 H), 8.24 (d, *J* = 5.7 Hz, 1 H), 8.60 (s, 1 H), 9.33 (s, 1 H), 11.7 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.9 (CH_2), 106.0 (C_{quat}), 107.0 (CH), 120.3 (CH), 121.7 (C_{quat}), 124.0 (CH), 127.9 (CH), 128.1 (CH), 128.7 (CH), 136.1 (C_{quat}), 139.7 (C_{quat}), 140.5 (CH), 141.9 (C_{quat}), 143.0 (CH). EI + MS (*m/z* (%)): 276 (19), 275 (M^+, 100), 248 (14), 247 (86), 246 ($(M\text{-}HN_2)^+$, 87), 220 (19), 219 (53), 170 (27), 156 ($C_9H_6N_3^+$, 61), 129 (38), 102 (13), 91 ($C_7H_7^+$, 99), 75 (13), 65 ($C_5H_5^+$, 22). IR (KBr): $\tilde{\nu}$ 3088 (s) cm^{-1}, 2975 (s), 2694 (s), 1627 (s), 1597 (s), 1578 (s), 1494 (w), 1464 (s), 1341 (m), 1299 (w), 1244 (m), 1212 (m), 1167 (w), 1117 (w), 1053 (m), 1026 (m), 938 (w), 901 (w), 854 (w), 806 (m), 769 (w), 716 (s), 693 (m), 650 (w), 631 (w), 596 (w), 505 (w). Anal. calcd for $C_{16}H_{13}N_5$ (275.3): C 69.80, H 4.76, N 25.44. Found: C 69.85, H 4.77, N 25.31.

4.2.5. 3-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-1*H*-pyrrolo[2,3-*c*]pyridine (8e)

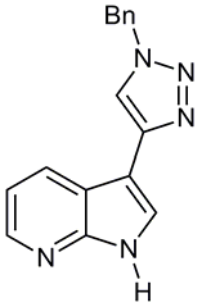


$C_{16}H_{13}N_5$

275.31

93 mg (0.34 mmol, 50 % yield over two steps) as a pale yellow solid. Further purified by suspension in DCM and sonication in ultrasound bath. Mp 226 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.66 (s, 2 H), 7.31-7.42 (m, 5 H), 7.98 (d, *J* = 5.4 Hz, 1 H), 8.03 (s, 1 H), 8.20 (d, *J* = 5.4 Hz, 1 H), 8.55 (s, 1 H), 8.80 (s, 1 H), 11.8 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.9 (CH_2), 105.9 (C_{quat}), 114.6 (CH), 120.0 (CH), 126.9 (CH), 127.9 (CH), 128.1 (CH), 128.8 (CH), 128.8 (C_{quat}), 133.5 (C_{quat}), 134.8 (CH), 136.2 (C_{quat}), 138.3 (CH), 142.0 (C_{quat}). EI + MS (*m/z* (%)): 276 (7), 275 (M^+, 34), 247 (47), 246 ($(M\text{-}HN_2)^+$, 100), 220 (14), 219 (55), 170 (28), 156 ($C_9H_6N_3^+$, 50), 129 (39), 102 (21), 91 ($C_7H_7^+$, 68), 75 (13), 65 ($C_5H_5^+$, 18). IR (KBr): $\tilde{\nu}$ 3068 (m) cm^{-1}, 2901 (m), 1655 (w), 1628 (m), 1560 (w), 1543 (w), 1499 (m), 1459 (s), 1340 (w), 1296 (w), 1225 (s), 1173 (w), 1125 (m), 1061 (m), 1041 (m), 1028 (m), 887 (w), 810 (m), 722 (m), 711 (w), 670 (w), 596 (w). Anal. calcd for $C_{16}H_{13}N_5$ (275.3): C 69.80, H 4.76, N 25.44. Found: C 69.88, H 4.96, N 25.24.

4.2.6. 3-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (8f)

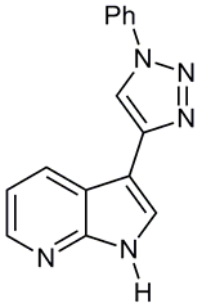


$C_{16}H_{13}N_5$

275.31

930 mg (3.38 mmol, 67 % yield over two steps) as a pale yellow solid. After suspension in dichloromethane, sonication in ultrasonic bath, filtration, and drying, a colorless solid was obtained. Mp 234-237 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.66 (s, 2 H), 7.17 (dd, *J* = 7.9 Hz, *J* = 4.7 Hz, 1 H), 7.32-7.43 (m, 5 H), 7.92 (d, *J* = 2.5 Hz, 1 H), 8.29 (dd, *J* = 4.7 Hz, *J* = 1.6 Hz, 1 H), 8.44 (dd, *J* = 7.9 Hz, *J* = 1.6 Hz, 1 H), 8.54 (s, 1 H), 11.9 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.8 (CH_2), 105.0 (C_{quat}), 115.9 (CH), 116.9 (C_{quat}), 119.8 (CH), 123.2 (CH), 127.8 (CH), 128.1 (CH), 128.3 (CH), 128.7 (CH), 136.1 (C_{quat}), 142.4 (C_{quat}), 143.1 (CH), 148.5 (C_{quat}). EI + MS (*m/z* (%)): 275 (M^+, 100), 248 (13), 247 (74), 246 (87), 220 (11), 219 (35), 170 (15), 156 (24), 142 (10), 129 (17), 91 ($C_7H_7^+$, 19), 44 (19). IR (KBr): $\tilde{\nu}$ 3133 (w) cm^{-1}, 1655 (w), 1626 (w), 1584 (s), 1498 (w), 1458 (m), 1420 (m), 1327 (w), 1286 (w), 1220 (m), 1130 (w), 1111 (w), 1058 (w), 941 (m), 897 (w), 799 (m), 771 (s), 722 (s), 587 (w). Anal. calcd for $C_{16}H_{13}N_5$ (275.3): C 69.80, H 4.76, N 25.44. Found: C 69.71, H 5.02, N 25.44.

4.2.7. 3-(1-Phenyl-1*H*-1,2,3-triazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (8g)

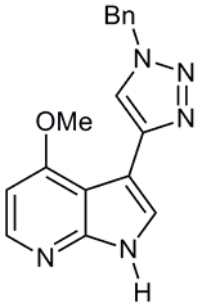


$C_{15}H_{11}N_5$

261.28

143 mg (0.55 mmol, 55 % yield over two steps) as a yellow solid. Mp 260 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 7.23 (dd, *J* = 7.9 Hz, *J* = 4.7 Hz, 1 H), 7.50-7.55 (m, 1 H), 7.63-7.68 (m, 2 H), 8.01-8.04 (m, 3 H), 8.34 (dd, *J* = 4.4 Hz, *J* = 0.9 Hz, 1 H), 8.58 (d, *J* = 7.9 Hz, 1 H), 9.18 (s, 1 H), 12.0 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 104.6 (C_{quat}), 116.1 (CH), 116.9 (C_{quat}), 117.5 (CH), 119.9 (CH), 123.6 (CH), 128.3 (CH), 128.4 (CH), 129.8 (CH), 136.7 (C_{quat}), 142.9 (C_{quat}), 143.3 (CH), 148.6 (C_{quat}). EI + MS (*m/z* (%)): 261 (M^+, 11), 234 (14), 233 ($C_5H_{11}N_3^+$, 88), 232 (100), 205 (31), 156 (43), 130 (15), 129 (15), 103 (29), 102 (19), 77 ($C_6H_5^+$, 13), 76 (11), 51 ($C_4H_3^+$, 10). IR (KBr): $\tilde{\nu}$ 3440 (s) cm^{-1}, 3080 (s), 2924 (w), 2852 (w), 1656 (w), 1623 (w), 1585 (s), 1545 (w), 1495 (m), 1460 (w), 1423 (s), 1322 (m), 1281 (m), 1236 (w), 1215 (m), 1157 (w), 1129 (w), 1113 (w), 1074 (w), 1044 (s), 993 (w), 933 (w), 895 (w), 832 (w), 799 (m), 757 (s), 692 (s), 647 (w), 626 (w), 584 (s), 538 (w), 518 (w). Anal. calcd for $C_{15}H_{11}N_5$ (261.3): C 68.95, H 4.24, N 26.80. Found: C 68.71, H 4.43, N 26.90.

4.2.8. 3-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-4-methoxy-1*H*-pyrrolo[2,3-*b*]pyridine (8h)

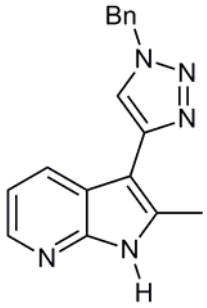


$C_{17}H_{15}N_5O$

305.33

109 mg (0.36 mmol, 48 % yield over two steps) as a yellow solid. Mp 253-258 °C (dec.). ^{1}H NMR (DMSO-d_6, 500 MHz): δ 3.92 (s, 3 H), 5.65 (s, 2 H), 6.68 (d, *J* = 5.4 Hz, 1 H), 7.32-7.43 (m, 5 H), 7.74 (d, *J* = 2.2 Hz, 1 H), 8.12 (d, *J* = 5.4 Hz, 1 H), 8.24 (s, 1 H), 11.8 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.6 (CH_2), 55.3 (CH_3), 98.2 (CH), 104.7 (C_{quat}), 106.4 (C_{quat}), 121.5 (CH), 122.1 (CH), 127.9 (CH), 128.1 (CH), 128.7 (CH), 136.4 (C_{quat}), 142.0 (C_{quat}), 145.2 (CH), 150.3 (C_{quat}), 159.6 (C_{quat}). EI + MS (*m/z* (%)): 306 (21), 305 (M^+, 100), 278 (17), 277 (83), 276 (86), 262 (27), 261 (11), 250 (12), 249 (38), 234 (10), 200 (16), 186 (31), 159 (14), 156 (18), 131 (12), 129 (11), 91 ($C_7H_7^+$, 58), 65 ($C_5H_5^+$, 12). IR (KBr): $\tilde{\nu}$ 3091 (w) cm^{-1}, 3007 (w), 2940 (w), 2842 (w), 1578 (s), 1512 (w), 1498 (w), 1459 (w), 1430 (w), 1410 (w), 1321 (m), 1308 (m), 1279 (m), 1222 (w), 1150 (w), 1098 (m), 1051 (w), 974 (w), 939 (w), 852 (w), 801 (m), 726 (m), 653 (w). Anal. calcd for $C_{17}H_{15}N_5O$ (305.3): C 66.87, H 4.95, N 22.94. Found: C 66.74, H 5.15, N 22.96.

4.2.9. 3-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-2-methyl-1*H*-pyrrolo[2,3-*b*]pyridine (8i)

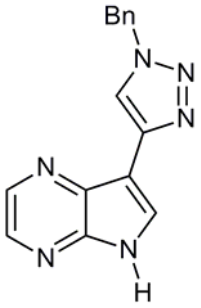


$C_{17}H_{15}N_5$

289.33

300 mg (1.04 mmol, 52 % yield over two steps) as a colorless solid. Mp 263 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 2.63 (s, 3 H), 5.67 (s, 2 H), 7.10 (dd, *J* = 7.9 Hz, *J* = 4.7 Hz, 1 H), 7.32-7.37 (m, 1 H), 7.38-7.41 (m, 4 H), 8.18 (dd, *J* = 4.7 Hz, *J* = 1.3 Hz, 1 H), 8.28 (dd, *J* = 7.6 Hz, *J* = 0.9 Hz, 1 H), 8.51 (s, 1 H), 11.8 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 13.0 (CH_3), 52.8 (CH_2), 101.0 (C_{quat}), 115.7 (CH), 118.5 (C_{quat}), 120.4 (CH), 126.9 (CH), 127.8 (CH), 128.0 (CH), 128.7 (CH), 134.1 (C_{quat}), 136.2 (C_{quat}), 141.8 (CH), 142.2 (C_{quat}), 147.8 (C_{quat}). EI + MS (*m/z* (%)): 289 (M^+, 64), 262 (18), 261 ($(M-N_2)^+$, 100), 260 (45), 246 (54), 233 (45), 232 (25), 231 (18), 219 (35), 184 (54), 170 (71), 157 (17), 156 (38), 155 (37), 143 (23), 132 (24), 131 (17), 130 (17), 129 (14), 116 (15), 103 (15), 102 (43), 91 ($C_7H_7^+$, 55), 65 ($C_5H_5^+$, 17). IR (KBr): $\tilde{\nu}$ 3425 (m) cm^{-1}, 3103 (w), 3035 (w), 2921 (w), 2850 (w), 1625 (w), 1585 (s), 1527 (m), 1494 (w), 1457 (m), 1417 (s), 1390 (w), 1279 (s), 1217 (s), 1138 (w), 1117 (w), 1070 (m), 1046 (w), 969 (w), 931 (s), 824 (w), 796 (m), 771 (s), 715 (s), 693 (w), 673 (m), 650 (w), 582 (w). Anal. calcd for $C_{17}H_{15}N_5$ (289.3): C 70.57, H 5.23, N 24.21. Found: C 70.33, H 5.20, N 24.25.

4.2.10. 7-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-5*H*-pyrrolo[2,3-*b*]pyrazine (8j)

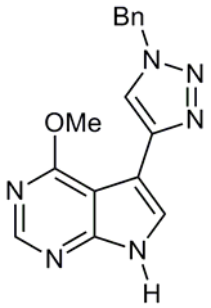


$C_{15}H_{12}N_6$

276.30

93 mg (0.34 mmol, 47 % yield over two steps) as a colorless solid. Mp 248-249 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.70 (s, 2 H), 7.31-7.37 (m, 1 H), 7.37-7.41 (m, 4 H), 8.31-8.35 (m, 2 H), 8.47 (d, *J* = 2.5 Hz, 1 H), 8.59 (s, 1 H), 12.3 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.7 (CH_2), 105.4 (C_{quat}), 120.8 (CH), 127.1 (CH), 127.9 (CH), 128.1 (CH), 128.7 (CH), 135.6 (C_{quat}), 136.2 (C_{quat}), 137.5 (CH), 138.3 (CH), 139.8 (C_{quat}), 141.7 (C_{quat}). EI + MS (*m/z* (%)): 276 (M^+, 50), 248 ($(M-N_2)^+$, 44), 247 ($(M-HN_2)^+$, 100), 220 (14), 157 ($C_8H_5N_4^+$, 48), 130 (12), 91 ($C_7H_7^+$, 39), 65 ($C_5H_5^+$, 8). IR (KBr): $\tilde{\nu}$ 3151 (s) cm^{-1}, 1632 (m), 1590 (m), 1544 (w), 1492 (m), 1456 (s), 1409 (m), 1364 (m), 1336 (s), 1221 (s), 1180 (m), 1119 (m), 1054 (m), 1038 (m), 944 (m), 908 (w), 849 (w), 799 (m), 721 (s), 694 (w), 673 (w), 628 (w), 586 (m), 540 (w). Anal. calcd for $C_{15}H_{12}N_6$ (276.3): C 65.21, H 4.38, N 30.42. Found: C 65.00, H 4.68, N 30.35.

4.2.11. 5-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-4-methoxy-7*H*-pyrrolo[2,3-*d*]pyrimidine (8k)

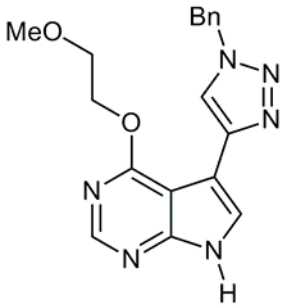


$C_{16}H_{14}N_6O$

306.32

165 mg (0.54 mmol, 54 % yield over two steps) as a colorless solid. Mp 249 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 4.07 (s, 3 H), 5.70 (s, 2 H), 7.34-7.45 (m, 5 H), 7.84 (s, 1 H), 8.38 (s, 1 H), 8.42 (s, 1 H), 12.3 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.6 (CH_2), 53.4 (CH_3), 101.4 (C_{quat}), 105.1 (C_{quat}), 121.4 (CH), 122.1 (CH), 127.9 (CH), 128.0 (CH), 128.7 (CH), 136.2 (C_{quat}), 141.0 (C_{quat}), 150.7 (CH), 152.7 (C_{quat}), 162.3 (C_{quat}). EI + MS (*m/z* (%)): 307 (7), 306 (M^+, 32), 278 ($(M-N_2)^+$, 54), 277 (90), 250 (26), 201 (13), 187 (46), 146 (14), 132 (12), 130 (22), 103 (14), 91 ($C_7H_7^+$, 100), 65 ($C_5H_5^+$, 20), 42 (11). IR (KBr): $\tilde{\nu}$ 3449 (w) cm^{-1}, 3084 (w), 2969 (w), 2923 (w), 2851 (w), 1581 (s), 1566 (s), 1476 (m), 1455 (m), 1433 (m), 1406 (w), 1376 (w), 1312 (s), 1219 (w), 1143 (w), 1091 (m), 1049 (m), 1031 (w), 962 (w), 936 (w), 880 (m), 851 (w), 798 (w), 771 (w), 720 (w), 691 (w), 671 (w), 633 (w), 575 (w). Anal. calcd for $C_{16}H_{14}N_6O$ (306.3): C 62.74, H 4.61, N 27.44. Found: C 62.78, H 4.53, N 27.67.

4.2.12. 4-(2-Methoxyethoxy)-5-(1-benzyl-1*H*-1,2,3-triazol-4-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (8l)

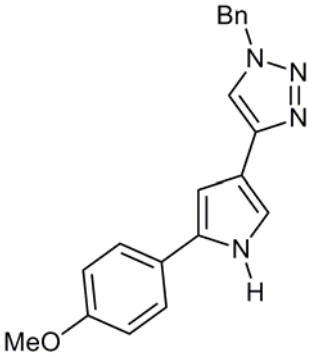


$C_{18}H_{18}N_6O_2$

350.37

141 mg (0.40 mmol, 41 % yield over two steps) as a colorless solid. Mp 240 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 3.23 (s, 3 H), 3.68-3.71 (m, 2 H), 4.57-4.60 (m, 2 H), 5.65 (s, 2 H), 7.29-7.36 (m, 3 H), 7.37-7.42 (m, 2 H), 7.85 (s, 1 H), 8.37 (s, 1 H), 8.43 (s, 1 H), 12.3 (br, 1 H, N<u>H</u>). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.9 (CH_2), 57.9 (CH_3), 64.7 (CH_2), 69.8 (CH_2), 101.3 (C_{quat}), 105.2 (C_{quat}), 121.5 (CH), 122.1 (CH), 127.4 (CH), 128.0 (CH), 128.8 (CH), 136.2 (C_{quat}), 141.3 (C_{quat}), 150.7 (CH), 152.8 (C_{quat}), 161.8 (C_{quat}). EI + MS (*m/z* (%)): 351 (24), 350 (M^+, 97), 322 (18), 321 (46), 264 (39), 263 (100), 236 (20), 231 (13), 201 (18), 173 (15), 161 (12), 148 (19), 146 (18), 111 (15), 109 (10), 97 (21), 95 (14), 91 ($C_7H_7^+$, 97), 85 (17), 83 (20), 81 (12), 71 (24), 69 (22), 65 ($C_5H_5^+$, 12), 59 (14), 57 (36), 55 (17), 43 (22). IR (KBr): $\tilde{\nu}$ 1578 (s) cm^{-1}, 1446 (m), 1321 (m), 1207 (w), 1143 (w), 1091 (m), 1028 (w), 905 (w), 721 (m), 629 (w). Anal. calcd for $C_{18}H_{18}N_6O_2$ (350.4): C 61.70, H 5.18, N 23.99. Found: C 61.59, H 5.22, N 24.10.

4.2.13. 1-Benzyl-4-(5-(4-methoxyphenyl)-1*H*-pyrrol-3-yl)-1*H*-1,2,3-triazole (8m)

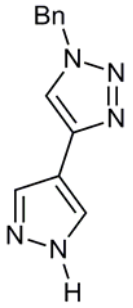


$C_{20}H_{18}N_4O$

330.38

147 mg (0.44 mmol, 44 % yield over two steps) as a pale yellow solid. Mp 238 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 3.76 (s, 3 H), 5.60 (s, 2 H), 6.70-6.72 (m, 1 H), 6.93-6.97 (m, 2 H), 7.18-7.20 (m, 1 H), 7.32-7.36 (m, 3 H), 7.37-7.41 (m, 2 H), 7.56-7.60 (m, 2 H), 8.16 (s, 1 H), 11.3 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.7 (CH_2), 55.0 (CH_3), 102.3 (CH), 114.1 (CH), 115.2 (C_{quat}), 115.8 (CH), 119.1 (CH), 124.7 (CH), 125.4 (C_{quat}), 127.8 (CH), 128.0 (CH), 128.7 (CH), 131.9 (C_{quat}), 136.2 (C_{quat}), 143.7 (C_{quat}), 157.5 (C_{quat}). EI + MS (*m/z* (%)): 331 (16), 330 (M^+, 66), 302 (40), 301 (100), 286 (11), 274 (34), 258 (12), 225 (11), 211 (36), 184 (21), 169 (13), 168 (17), 167 (13), 141 (10), 140 (12), 134 (23), 91 ($C_7H_7^+$, 48), 65 ($C_5H_5^+$, 10). IR (KBr): $\tilde{\nu}$ 3429 (s) cm^{-1}, 1655 (w), 1638 (w), 1560 (w), 1543 (w), 1501 (m), 1458 (w), 1290 (w), 1256 (m), 1051 (m), 1022 (m), 835 (m), 798 (m), 718 (m), 548 (m). Anal. calcd for $C_{20}H_{18}N_4O$ (330.4): C 72.71, H 5.49, N 16.96. Found: C 72.45, H 5.68, N 17.08.

4.2.14. 1-Benzyl-4-(1*H*-pyrazol-4-yl)-1*H*-1,2,3-triazole (8n)

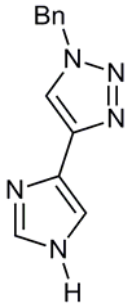


$C_{12}H_{11}N_5$

225.25

86 mg (0.38 mmol, 38 % yield over two steps) as a colorless solid. Mp 218 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.60 (s, 2 H), 7.31-7.35 (m, 3 H), 7.36-7.41 (m, 2 H), 7.7-8.2 (br, 2 H), 8.25 (s, 1 H), 13.0 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.8 (CH_2), 111.8 (C_{quat}), 120.2 (CH), 127.9 (CH), 128.1 (CH), 128.8 (CH), 136.0 (C_{quat}), 140.6 (C_{quat}). EI + MS (*m/z* (%)): 225 (M^+, 18), 196 ($(M-HN_2)^+$, 72), 169 (27), 167 (10), 143 (16), 106 ($C_7H_8N^+$, 96), 104 (10), 91 ($C_7H_7^+$, 100), 79 ($C_4H_3N_2^+$, 15), 65 ($C_5H_5^+$, 24), 51 ($C_4H_3^+$, 10). IR (KBr): $\tilde{\nu}$ 3122 (s) cm^{-1}, 3064 (m), 2952 (m), 2878 (m), 1630 (m), 1544 (w), 1496 (w), 1458 (m), 1390 (w), 1360 (m), 1270 (w), 1215 (m), 1142 (w), 1111 (w), 1077 (w), 1049 (m), 1018 (w), 965 (w), 934 (m), 885 (m), 830 (s), 812 (s), 717 (s), 707 (s), 669 (w), 650 (w), 624 (m), 590 (w). Anal. calcd for $C_{12}H_{11}N_5$ (225.3): C 63.99, H 4.92, N 31.09. Found: C 63.75, H 5.05, N 31.10.

4.2.15. 1-Benzyl-4-(1*H*-imidazol-4-yl)-1*H*-1,2,3-triazole (8o)

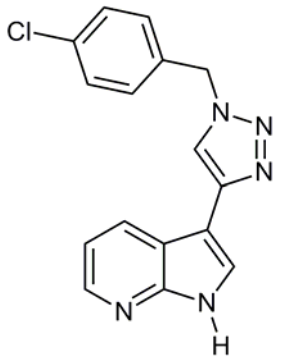


$C_{12}H_{11}N_5$

225.25

46 mg (0.20 mmol, 20 % yield over two steps) as a colorless solid. Mp 188 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.62 (s, 2 H), 7.29-7.41 (m, 5 H), 7.5 (br, 1 H), 7.70 (s, 1 H), 8.2 (br, 1 H), 12.2 & 12.7 (br, 1 H, NH). EI + MS (*m/z* (%)): 225 (M^+, 30), 197 ($(M-N_2)^+$, 18), 196 ($(M-HN_2)^+$, 100), 169 (37), 149 (13), 143 (10), 142 (12), 120 (16), 115 (11), 106 ($C_7H_8N^+$, 86), 105 (11), 93 (11), 92 (18), 91 ($C_7H_7^+$, 90), 85 (10), 77 ($C_6H_5^+$, 18), 71 (12), 65 ($C_5H_5^+$, 25), 57 (13), 55 (10), 52 ($C_4H_4^+$, 11), 44 (10), 43 (10), 41 (11). IR (KBr): $\tilde{\nu}$ 3113 (s) cm^{-1}, 3032 (m), 2925 (m), 2832 (m), 1655 (w), 1625 (m), 1535 (m), 1498 (w), 1458 (s), 1354 (w), 1215 (s), 1162 (w), 1121 (w), 1097 (w), 1054 (w), 1016 (w), 945 (s), 833 (m), 787 (w), 715 (s), 693 (m), 660 (w), 627 (w), 583 (w). Anal. calcd for $C_{12}H_{11}N_5$ (225.3): C 63.99, H 4.92, N 31.09. Found: C 64.08, H 5.08, N 30.85.

4.2.16. 3-(1-(4-Chlorobenzyl)-1*H*-1,2,3-triazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (8p)

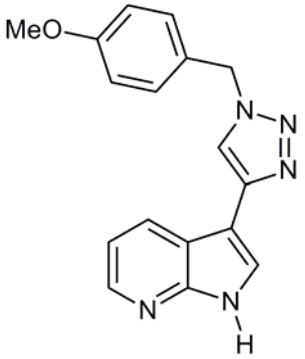


$C_{16}H_{12}ClN_5$

309.75

218 mg (0.70 mmol, 45 % yield over two steps) as a colorless solid. Mp 225 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.67 (s, 2 H), 7.18 (dd, *J* = 7.9 Hz, *J* = 4.7 Hz, 1 H), 7.38-7.43 (m, 2 H), 7.45-7.50 (m, 2 H), 7.92 (d, *J* = 2.2 Hz, 1 H), 8.29 (d, *J* = 4.4 Hz, 1 H), 8.44 (d, *J* = 7.9 Hz, 1 H), 8.53 (s, 1 H), 11.9 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.0 (CH_2), 104.9 (C_{quat}), 115.9 (CH), 116.9 (C_{quat}), 119.8 (CH), 123.3 (CH), 128.2 (CH), 128.7 (CH), 129.8 (CH), 132.8 (C_{quat}), 135.1 (C_{quat}), 142.4 (C_{quat}), 143.1 (CH), 148.5 (C_{quat}). EI + MS (*m/z* (%)): 311 ($M(^{37}Cl)^+$, 26), 310 (14), 309 ($M(^{35}Cl)^+$, 80), 283 (27), 282 (44), 281 (75), 280 (100), 253 (20), 246 (20), 219 (16), 218 (19), 170 (26), 156 (54), 129 (35), 127 (15), 125 (45), 118 (11), 102 (18), 89 (17), 57 (12), 44 (24). IR (KBr): $\tilde{\nu}$ 3139 (m) cm^{-1}, 2895 (w), 1625 (w), 1584 (s), 1493 (s), 1418 (m), 1326 (w), 1286 (w), 1222 (w), 1130 (w), 1091 (w), 1054 (w), 1016 (w), 941 (w), 897 (w), 801 (m), 771 (s), 653 (w), 619 (w), 586 (w). Anal. calcd for $C_{16}H_{12}ClN_5$ (309.8): C 62.04, H 3.90, N 22.61. Found: C 61.92, H 3.90, N 22.54.

4.2.17. 3-(1-(4-Methoxybenzyl)-1*H*-1,2,3-triazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (8q)

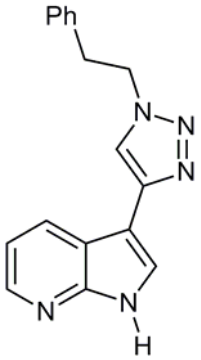


$C_{17}H_{15}N_5O$

305.33

179 mg (0.58 mmol, 58 % yield over two steps) as a pale yellow solid. After suspension in dichloromethane, sonication in ultrasonic bath, filtration, and drying, a colorless solid was obtained. Mp 185 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 3.74 (s, 3 H), 5.57 (s, 2 H), 6.94-6.97 (m, 2 H), 7.17 (dd, *J* = 7.9 Hz, *J* = 4.7 Hz, 1 H), 7.34-7.38 (m, 2 H), 7.90 (d, *J* = 2.5 Hz, 1 H), 8.28 (dd, *J* = 4.7 Hz, *J* = 1.6 Hz, 1 H), 8.44 (dd, *J* = 7.9 Hz, *J* = 1.3 Hz, 1 H), 8.48 (s, 1 H), 11.9 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 52.4 (CH_2), 55.0 (CH_3), 105.0 (C_{quat}), 114.0 (CH), 115.9 (CH), 116.9 (C_{quat}), 119.4 (CH), 123.2 (CH), 128.0 (C_{quat}), 128.2 (CH), 129.5 (CH), 142.3 (C_{quat}), 143.1 (CH), 148.5 (C_{quat}), 159.0 (C_{quat}). EI + MS (*m/z* (%)): 306 (7), 305 (M^+, 36), 277 ((M-N_2)$^+$, 43), 276 (72), 249 (19), 170 (18), 156 (40), 129 (36), 122 (11), 121 ($C_8H_9O^+$, 100), 103 (10), 102 (13), 91 ($C_7H_7^+$, 13), 78 ($C_6H_6^+$, 19), 77 ($C_6H_5^+$, 20). IR (KBr): $\tilde{\nu}$ 3447 (m) cm^{-1}, 3424 (m), 3136 (w), 2903 (w), 1612 (w), 1584 (m), 1514 (s), 1462 (w), 1419 (m), 1335 (w), 1281 (w), 1249 (s), 1211 (w), 1180 (w), 1127 (w), 1033 (m), 938 (w), 896 (w), 827 (w), 798 (w), 764 (s), 697 (w), 618 (w), 588 (w), 552 (w). Anal. calcd for $C_{17}H_{15}N_5O$ (305.3): C 66.87, H 4.95, N 22.94. Found: C 66.68, H 5.20, N 23.03.

4.2.18. 3-(1-Phenethyl-1*H*-1,2,3-triazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (8r)

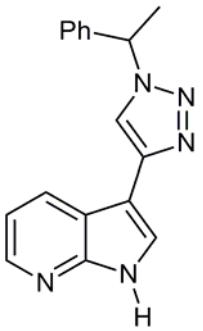


$C_{17}H_{15}N_5$

289.33

179 mg (0.62 mmol, 62 % yield over two steps) as a colorless solid. Mp 228 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 3.26 (t, *J* = 7.3 Hz, 2 H), 4.68 (t, *J* = 7.3 Hz, 2 H), 7.18 (dd, *J* = 7.9 Hz, *J* = 4.4 Hz, 1 H), 7.20-7.32 (m, 5 H), 7.89 (d, *J* = 2.2 Hz, 1 H), 8.30 (dd, *J* = 4.4 Hz, *J* = 1.6 Hz, 1 H), 8.40 (dd, *J* = 7.9 Hz, *J* = 1.6 Hz, 1 H), 8.44 (s, 1 H), 11.9 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 35.5 (CH_2), 50.4 (CH_2), 105.1 (C_{quat}), 115.9 (CH), 116.9 (C_{quat}), 119.6 (CH), 123.0 (CH), 126.5 (CH), 128.1 (CH), 128.3 (CH), 128.6 (CH), 137.6 (C_{quat}), 141.7 (C_{quat}), 143.1 (CH), 148.5 (C_{quat}). EI + MS (*m/z* (%)): 289 (M^+, 40), 261 ($(M-N_2)^+$, 13), 260 (13), 234 (16), 233 (36), 171 (12), 170 (100), 157 (15), 156 (18), 144 (11), 143 (80), 142 (28), 132 (12), 131 (20), 130 (14), 129 (13), 116 (20), 115 (18), 105 ($C_8H_9^+$, 24), 103 (17), 91 ($C_7H_7^+$, 12), 79 (15), 77 ($C_6H_5^+$, 18). IR (KBr): $\tilde{\nu}$ 3449 (w) cm^{-1}, 3089 (m), 3064 (m), 3028 (w), 2932 (w), 2893 (w), 1624 (w), 1584 (s), 1495 (m), 1455 (m), 1416 (s), 1320 (w), 1283 (m), 1218 (m), 1134 (w), 1112 (w), 1058 (w), 1030 (m), 942 (w), 898 (w), 842 (w), 793 (m), 770 (s), 730 (s), 698 (s), 629 (w), 585 (w). Anal. calcd for $C_{17}H_{15}N_5$ (289.3): C 70.57, H 5.23, N 24.21. Found: C 70.47, H 5.40, N 24.25.

4.2.19. 3-(1-(1-Phenylethyl)-1*H*-1,2,3-triazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridin (8s)

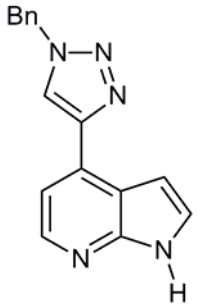


$C_{17}H_{15}N_5$

289.33

160 mg (0.55 mmol, 55 % yield over two steps) as a pale yellow solid. Mp 184 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 1.96 (d, *J* = 7.3 Hz, 3 H), 6.00 (q, *J* = 7.3 Hz, 1 H), 7.18 (dd, *J* = 7.9 Hz, *J* = 4.7 Hz, 1 H), 7.30-7.35 (m, 1 H), 7.37-7.40 (m, 4 H), 7.91 (d, *J* = 2.5 Hz, 1 H), 8.29 (dd, *J* = 4.4 Hz, *J* = 1.6 Hz, 1 H), 8.48 (dd, *J* = 7.9 Hz, *J* = 1.3 Hz, 1 H), 8.62 (s, 1 H), 11.9 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 21.0 (CH_3), 59.2 (CH), 105.1 (C_{quat}), 115.9 (CH), 116.9 (C_{quat}), 118.3 (CH), 123.2 (CH), 126.2 (CH), 127.9 (CH), 128.3 (CH), 128.7 (CH), 141.2 (C_{quat}), 142.1 (C_{quat}), 143.1 (CH), 148.5 (C_{quat}). EI + MS (*m/z* (%)): 290 (6), 289 (M^+, 30), 260 (13), 247 (19), 246 (100), 219 (12), 156 (47), 143 (11), 129 (35), 105 ($C_8H_9^+$, 34), 103 (17), 102 (12), 79 (13), 77 ($C_6H_5^+$, 17). IR (KBr): $\tilde{\nu}$ 3457 (w) cm^{-1}, 3120 (m), 3080 (m), 2927 (m), 2874 (m), 1623 (w), 1586 (s), 1495 (w), 1458 (m), 1420 (m), 1383 (w), 1333 (m), 1302 (w), 1279 (m), 1234 (w), 1211 (m), 1196 (m), 1136 (m), 1109 (w), 1058 (w), 1040 (w), 1023 (w), 982 (w), 937 (m), 896 (w), 824 (m), 793 (w), 770 (s), 722 (w), 694 (m), 648 (w), 624 (w), 584 (m), 544 (w), 526 (w). Anal. calcd for $C_{17}H_{15}N_5$ (289.3): C 70.57, H 5.23, N 24.21. Found: C 70.30, H 5.42, N 24.01.

4.2.20. 4-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (9a)

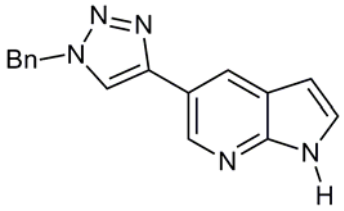


$C_{16}H_{13}N_5$

275.31

207 mg (0.75 mmol, 75 % yield over two steps) as a colorless solid. Mp 200 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.73 (s, 2 H), 7.00-7.03 (m, 1 H), 7.33-7.44 (m, 5 H), 7.58-7.61 (m, 2 H), 8.29 (dd, *J* = 5.0 Hz, *J* = 0.6 Hz, 1 H), 9.03 (d, *J* = 0.9 Hz, 1 H), 11.8 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 53.0 (CH_2), 100.1 (CH), 111.6 (CH), 115.5 (C_{quat}), 123.8 (CH), 126.5 (CH), 127.9 (CH), 128.1 (CH), 128.7 (CH), 129.3 (C_{quat}), 135.9 (C_{quat}), 142.6 (CH), 144.8 (C_{quat}), 149.4 (C_{quat}). EI + MS (*m/z* (%)): 276 (10), 275 (M^+, 48), 247 (14), 246 (64), 219 (14), 170 (10), 157 (11), 156 (100), 149 (20), 130 (14), 129 (30), 109 (10), 102 (10), 91 ($C_7H_7^+$, 98), 85 (11), 71 (13), 65 ($C_5H_5^+$, 14), 57 (14). IR (KBr): $\tilde{\nu}$ 3128 (m) cm^{-1}, 2869 (m), 1604 (s), 1543 (w), 1498 (m), 1458 (m), 1391 (w), 1333 (s), 1226 (w), 1050 (m), 897 (w), 824 (s), 723 (m), 645 (w), 601 (w). Anal. calcd for $C_{16}H_{13}N_5$ (275.3): C 69.80, H 4.76, N 25.44. Found: C 69.58, H 4.83, N 25.58.

4.2.21. 5-(1-Benzyl-1*H*-1,2,3-triazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (9b)

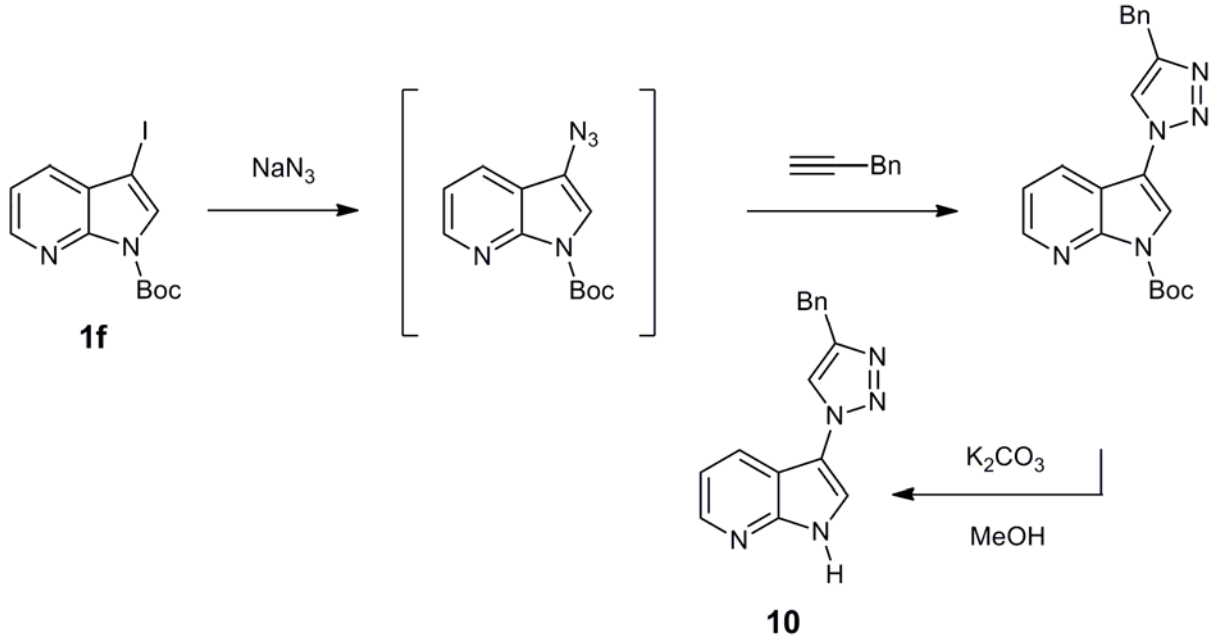


$C_{16}H_{13}N_5$

275.31

182 mg (0.66 mmol, 66 % yield over two steps) as a colorless solid. Mp 210 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.65 (s, 2 H), 6.50 (dd, *J* = 3.5 Hz, *J* = 1.9 Hz, 1 H), 7.32-7.43 (m, 5 H), 7.49-7.51 (m, 1 H), 8.38 (d, *J* = 1.9 Hz, 1 H), 8.64 (s, 1 H), 8.71 (d, *J* = 1.9 Hz, 1 H), 11.7 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 53.1 (CH_2), 100.2 (CH), 118.9 (C_{quat}), 119.5 (C_{quat}), 120.8 (CH), 124.6 (CH), 127.0 (CH), 128.0 (CH), 128.2 (CH), 128.8 (CH), 136.0 (C_{quat}), 140.4 (CH), 145.7 (C_{quat}), 148.2 (C_{quat}). EI + MS (*m/z* (%)): 276 (6), 275 (M^+, 28), 247 (23), 246 (100), 219 (25), 170 (22), 156 (68), 129 (39), 91 ($C_7H_7^+$, 58), 65 ($C_5H_5^+$, 11). IR (KBr): $\tilde{\nu}$ 3125 (m) cm^{-1}, 1608 (w), 1585 (w), 1497 (w), 1454 (w), 1435 (w), 1407 (m), 1340 (m), 1314 (w), 1298 (w), 1228 (w), 1214 (w), 1069 (w), 1051 (w), 919 (w), 905 (w), 805 (m), 781 (w), 734 (s), 693 (w), 621 (w), 505 (w). Anal. calcd for $C_{16}H_{13}N_5$ (275.3): C 69.80, H 4.76, N 25.44. Found: C 69.95, H 4.64, N 25.48.

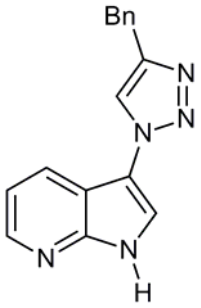
5. Preparation of 3-(4-Benzyl-1*H*-1,2,3-triazol-1-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (10) by the One-Pot Synthesis of 1-Aryl 1,2,3-Triazoles from Aryl Halides and Terminal Alkynes in the Presence of Sodium Azide[4]



Copper(I) iodide (39 mg, 0.20 mmol, 10 mol %) was placed under argon atmosphere in a dry screw-cap vessel with septum. Then, *tert*-butyl 3-iodo-1*H*-pyrrolo[2,3-*b*]pyridine-1-carboxylate (**1f**) (688 mg, 2.00 mmol) in 5 mL of dimethylsulfoxide and 1mL of water was added and the mixture was degassed with argon. Sodium azide (138 mg, 2.10 mmol, 1.05 equiv), sodium ascorbate (40 mg, 0.20 mmol, 10 mol %), benzylacetylene (0.26 mL, 2.00 mmol, 1.00 equiv), and 4,4,5,5-tetramethyl-1,3,2-dioxaborolane (0.22 mL, 0.30 mmol, 0.15 equiv) were successively added to the mixture which was stirred at room temperature (water bath) for 112 h (monitored by TLC, but the reaction did not go to completion). Then, the mixture was diluted with 10 mL of water, extracted with 10 mL of dichloromethane, the organic phase was washed with water (3 x 10 mL), dried with sodium sulphate, and filtered. The solvents were removed in vacuo and the residue was absorbed onto Celite® and purified chromatographically on silica gel with petroleum ether (boiling range 40-60 °C)/ethyl acetate (PE-EtOAc = 5:1). After drying in vacuo, 105 mg (0.28 mmol, 14 % yield) of a yellow oil were obtained.

The obtained oil was dissolved in 1.4 mL of methanol, potassium carbonate (98 mg, 0.70 mmol, 2.50 equiv) was added, and the mixture was stirred at room temperature for 1 h. Then, the solvent was removed in vacuo and the residue was absorbed onto Celite® and purified chromatographically on silica gel with dichloromethane-methanol-aqueous ammonia DCM-MeOH-NH_3 = 100:1:1 → 100:2:1 → 100:3:1 → 100:4:1 (stepwise gradient). After drying in vacuo at 70 °C overnight, 3-(1-benzyl-1*H*-pyrazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (**10**) (49 mg, 0.18 mmol, 64 % yield) was obtained as a colorless solid.

3-(4-Benzyl-1*H*-1,2,3-triazol-1-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (10)

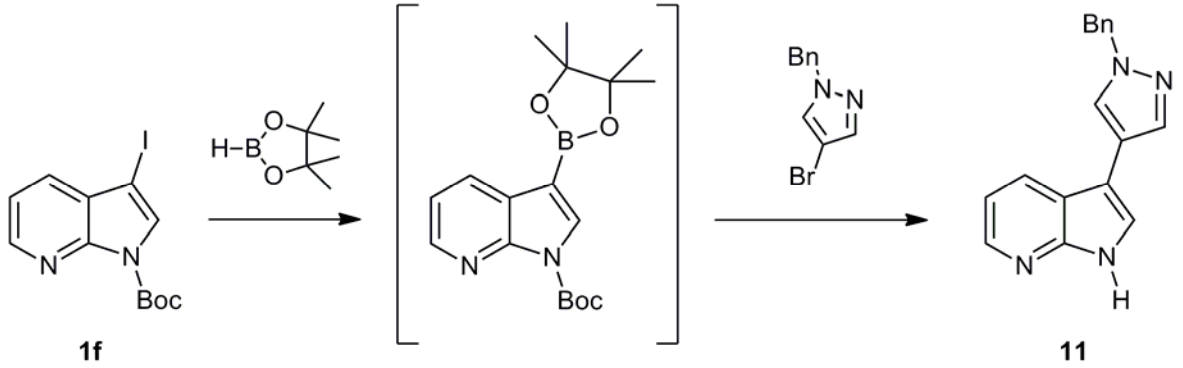


$C_{16}H_{13}N_5$

275.31

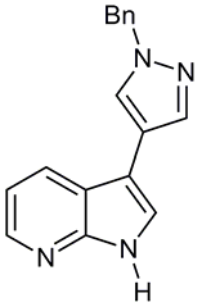
49 mg (9 % yield over two steps) as a colorless solid. Mp 177 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 4.11 (s, 2 H), 7.21-7.26 (m, 2 H), 7.30-7.35 (m, 4 H), 8.11 (d, *J* = 2.8 Hz, 1 H), 8.30 (dd, *J* = 7.9 Hz, *J* = 1.6 Hz, 1 H), 8.37 (dd, *J* = 4.4 Hz, *J* = 1.6 Hz, 1 H), 8.46 (s, 1 H), 12.2 (br, 1 H, NH). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 31.1 (CH_2), 112.2 (C_{quat}), 113.6 (C_{quat}), 116.7 (CH), 117.6 (CH), 121.4 (CH), 126.1 (CH), 127.5 (CH), 128.4 (CH), 128.5 (CH), 139.3 (C_{quat}), 144.3 (CH), 146.1 (C_{quat}), 146.4 (C_{quat}). EI + MS (*m/z* (%)): 275 (M^+, 1), 247 ($(M-N_2)^+$, 37), 246 (100), 170 (27), 144 (32), 143 (44), 132 (16), 128 (10), 117 (15), 116 (11), 115 (14), 104 (37), 103 (15), 91 ($C_7H_7^+$, 18), 90 (15), 78 (10), 77 ($C_6H_5^+$, 14), 65 ($C_5H_5^+$, 5). IR (KBr): $\tilde{\nu}$ 3447 (s) cm^{-1}, 3421 (s), 3144 (w), 3108 (w), 3025 (w), 2920 (w), 2821 (w), 1655 (m), 1613 (s), 1586 (m), 1563 (w), 1515 (w), 1494 (m), 1436 (m), 1409 (s), 1377 (m), 1341 (w), 1288 (s), 1206 (s), 1136 (m), 1103 (m), 1073 (w), 1049 (s), 1021 (w), 947 (m), 895 (m), 830 (w), 790 (m), 766 (s), 721 (s), 691 (m), 665 (w), 616 (w), 586 (m), 531 (w). Anal. calcd for $C_{16}H_{13}N_5$ (275.3): C 69.80, H 4.76, N 25.44. Found: C 69.63, H 4.96, N 25.20.

6. Preparation of 3-(1-Benzyl-1*H*-pyrazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (11) by the *Masuda* Borylation – *Suzuki* Coupling Sequence[5]



Tetrakis(triphenylphosphane)-palladium(0) (35 mg, 0.03 mmol, 3 mol %) and *tert*-butyl 3-iodo-1*H*-pyrrolo[2,3-*b*]pyridine-1-carboxylate (**1f**) (344 mg, 1.00 mmol) were placed under argon atmosphere in a dry screw-cap vessel with septum. Then, 5 mL of dry dioxane were added and the mixture was degassed with argon. Dry triethylamine (1.39 mL, 10.0 mmol, 10.0 equiv), and 4,4,5,5-tetramethyl-1,3,2-dioxaborolane (0.22 mL, 1.50 mmol, 1.50 equiv) were successively added to the mixture which was stirred at 80 °C (preheated oil bath) for 3 h (monitored by TLC). Then, after cooling to room temperature (water bath), 5 mL of dry methanol, 1-benzyl-4-bromo-1*H*-pyrazole (237 mg 1.00 mmol, 1.00 equiv), and cesium carbonate (823 mg, 2.50 mmol, 2.50 equiv) were successively added and the mixture was stirred at 100 °C (preheated oil bath) for 24 h. Then, after cooling to room temperature (water bath) the solvents were removed in vacuo and the residue was absorbed onto Celite® and purified chromatographically on silica gel with dichloromethane-methanol-aqueous ammonia DCM-MeOH-NH_3 = 100:1:1. After drying in vacuo at 70 °C overnight, 3-(1-benzyl-1*H*-pyrazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (**11**) was obtained as a yellow solid. Recrystallization from dichloromethane/*n*-pentane gave a colorless solid.

3-(1-Benzyl-1*H*-pyrazol-4-yl)-1*H*-pyrrolo[2,3-*b*]pyridine (11)

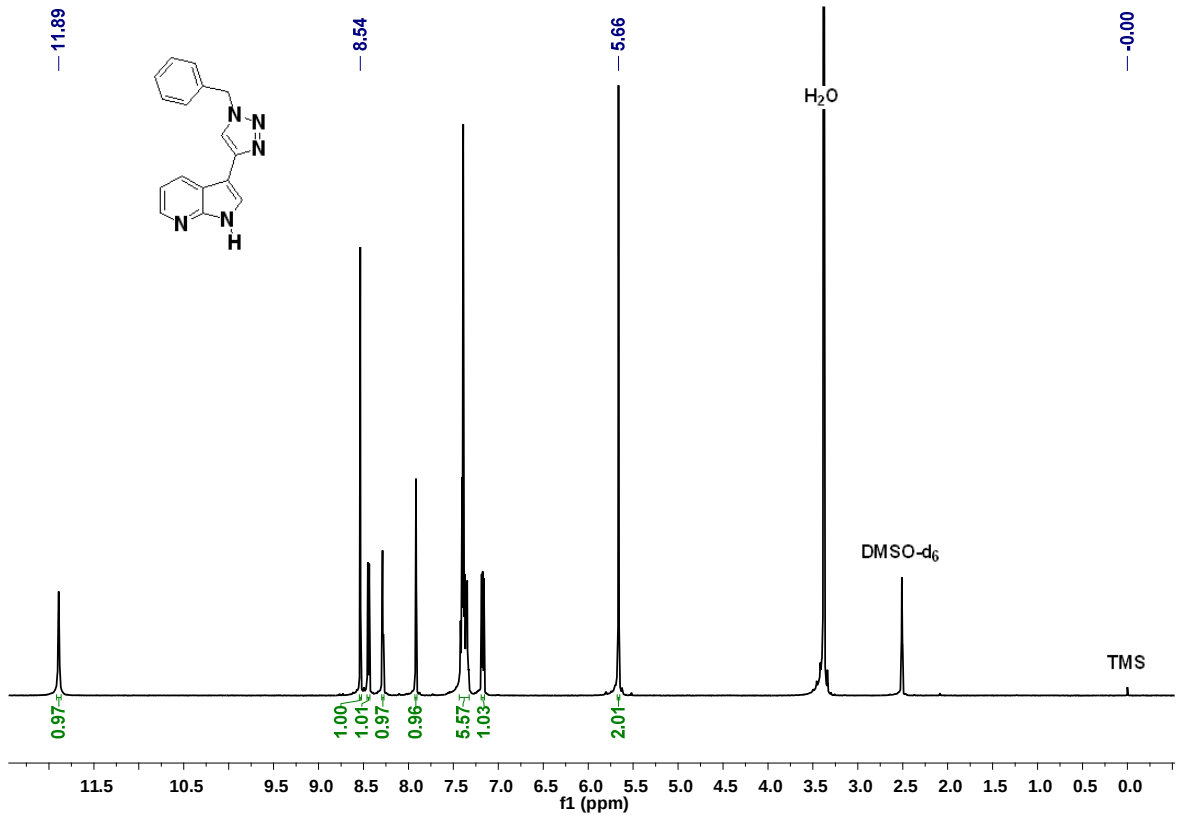


$C_{17}H_{14}N_4$

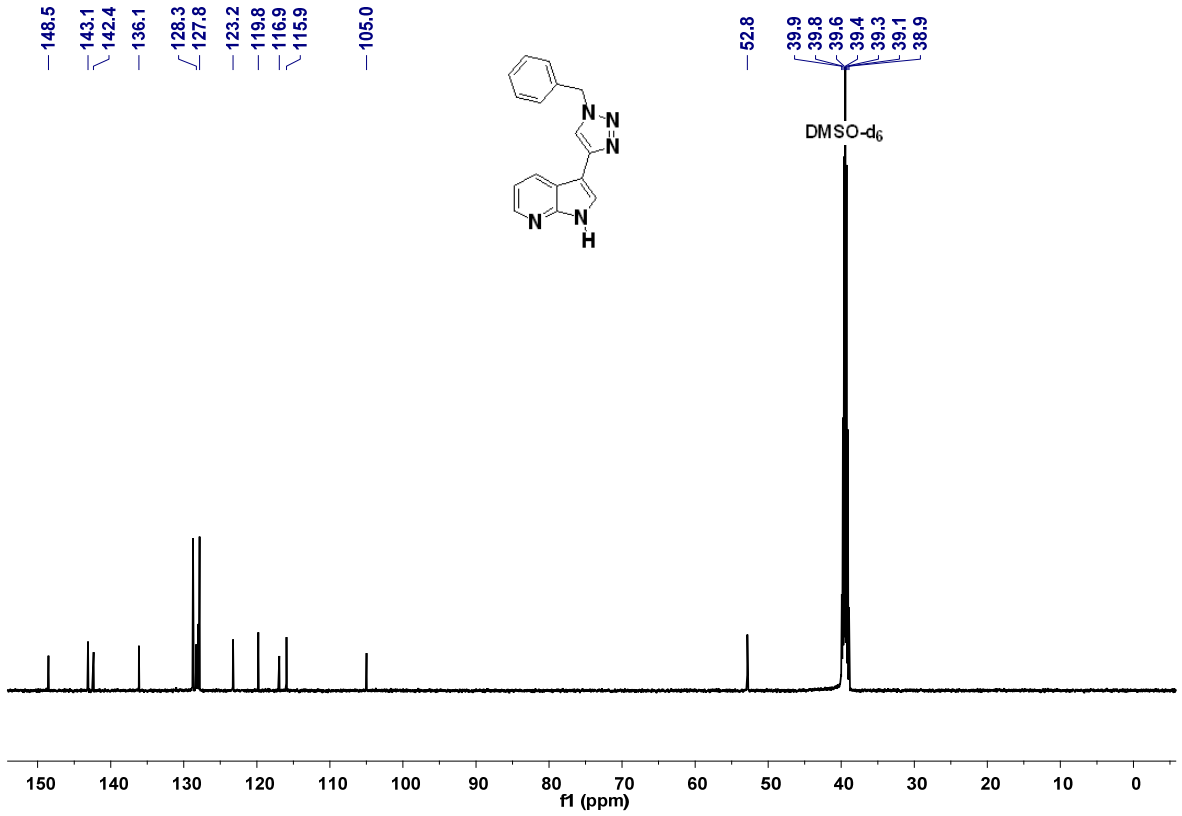
274.32

41 mg (0.15 mmol, 15 % yield) as a colorless solid (dichloromethane/*n*-pentane). Mp 198 °C. ^{1}H NMR (DMSO-d_6, 500 MHz): δ 5.37 (s, 2 H), 7.12 (dd, *J* = 7.9 Hz, *J* = 4.4 Hz, 1 H), 7.26-7.32 (m, 3 H), 7.33-7.38 (m, 2 H), 7.71 (d, *J* = 2.5 Hz, 1 H), 7.90 (s, 1 H), 8.21 (dd, *J* = 7.9 Hz, *J* = 1.3 Hz, 1 H), 8.24 (dd, *J* = 4.4 Hz, *J* = 1.3 Hz, 1 H), 8.29 (s, 1 H), 11.7 (br, 1 H, N<u>H</u>). ^{13}C NMR (DMSO-d_6, 125 MHz): δ 54.8 (CH_2), 106.2 (C_{quat}), 115.4 (CH), 115.6 (C_{quat}), 117.2 (C_{quat}), 121.9 (CH), 126.3 (CH), 127.4 (CH), 127.5 (CH), 127.5 (CH), 128.5 (CH), 136.5 (CH), 137.7 (C_{quat}), 142.7 (CH), 148.6 (C_{quat}). EI + MS (*m/z* (%)): 275 (26), 274 (M^+, 100), 273 ($(M-H)^+$, 10), 183 ($C_{10}H_7N_4^+$, 9), 142 ($C_9H_6N_2^+$, 7), 91 ($C_7H_7^+$, 51), 65 ($C_5H_5^+$, 6). IR (KBr): $\tilde{\nu}$ 3449 (w) cm^{-1}, 3103 (m), 3027 (m), 2819 (m), 1655 (w), 1579 (m), 1492 (m), 1459 (w), 1421 (s), 1337 (w), 1288 (m), 1229 (w), 1196 (w), 1149 (w), 1130 (w), 1110 (w), 989 (m), 918 (w), 897 (w), 857 (m), 822 (w), 793 (w), 763 (s), 719 (s), 695 (w), 665 (w), 650 (w), 614 (w), 587 (w), 532 (w). Anal. calcd for $C_{17}H_{14}N_4$ (274.3): C 74.43, H 5.14, N 20.42. Found: C 74.41, H 5.22, N 20.27.

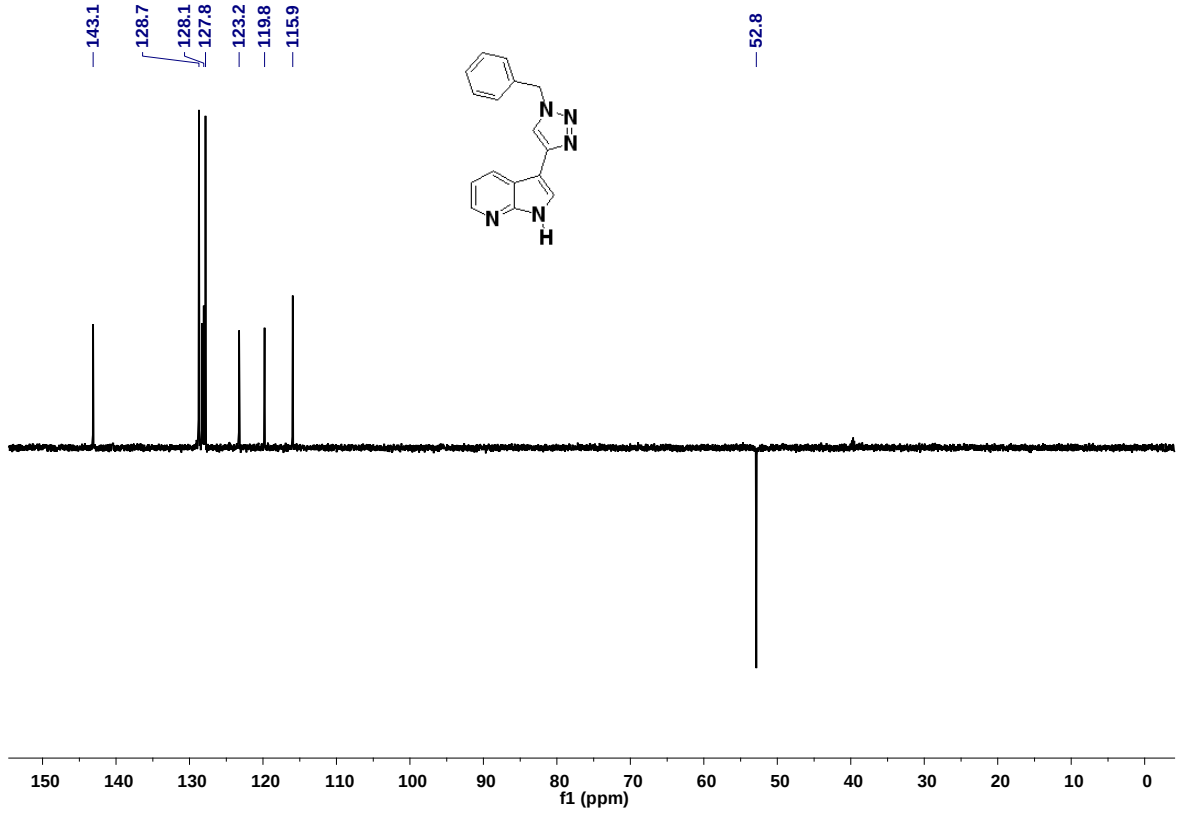
7. ^{1}H and ^{13}C NMR Spectra of Compounds 8f, 8g, 8r, 9a, 10, and 11



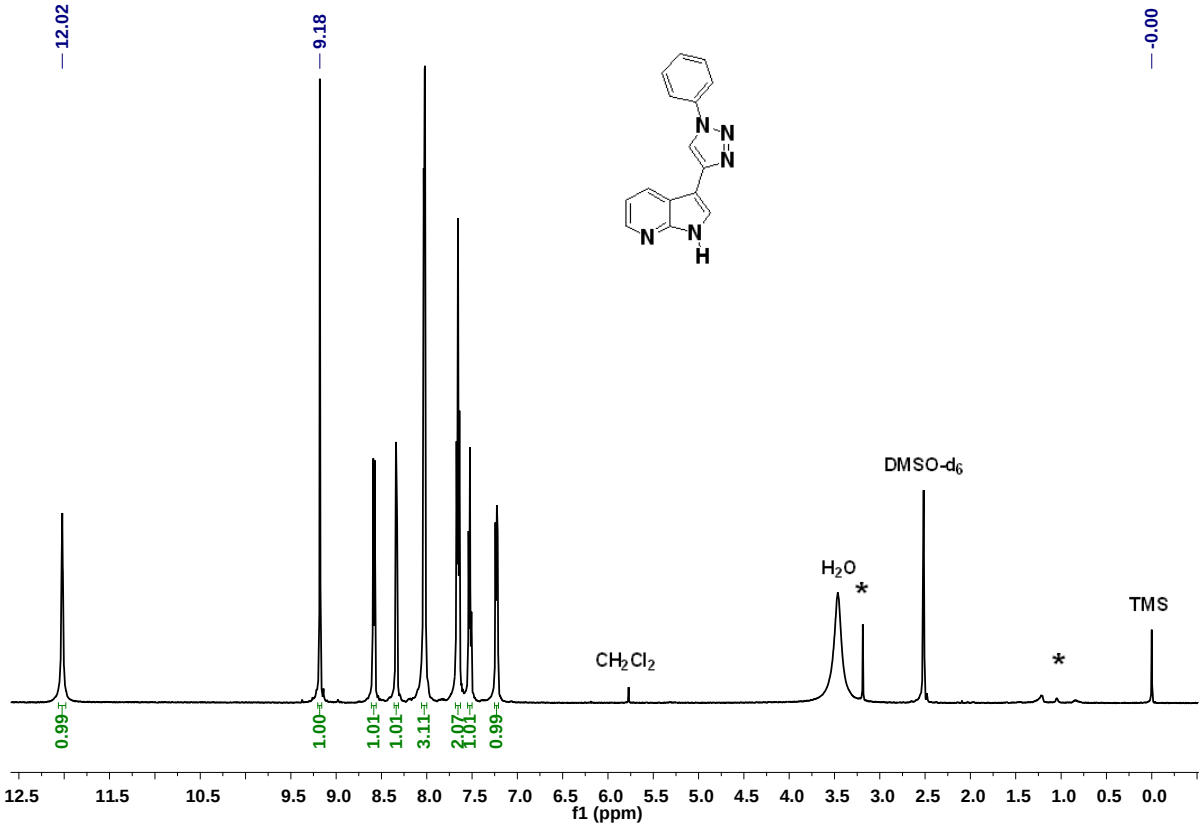
^{1}H NMR of **8f** (15 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).



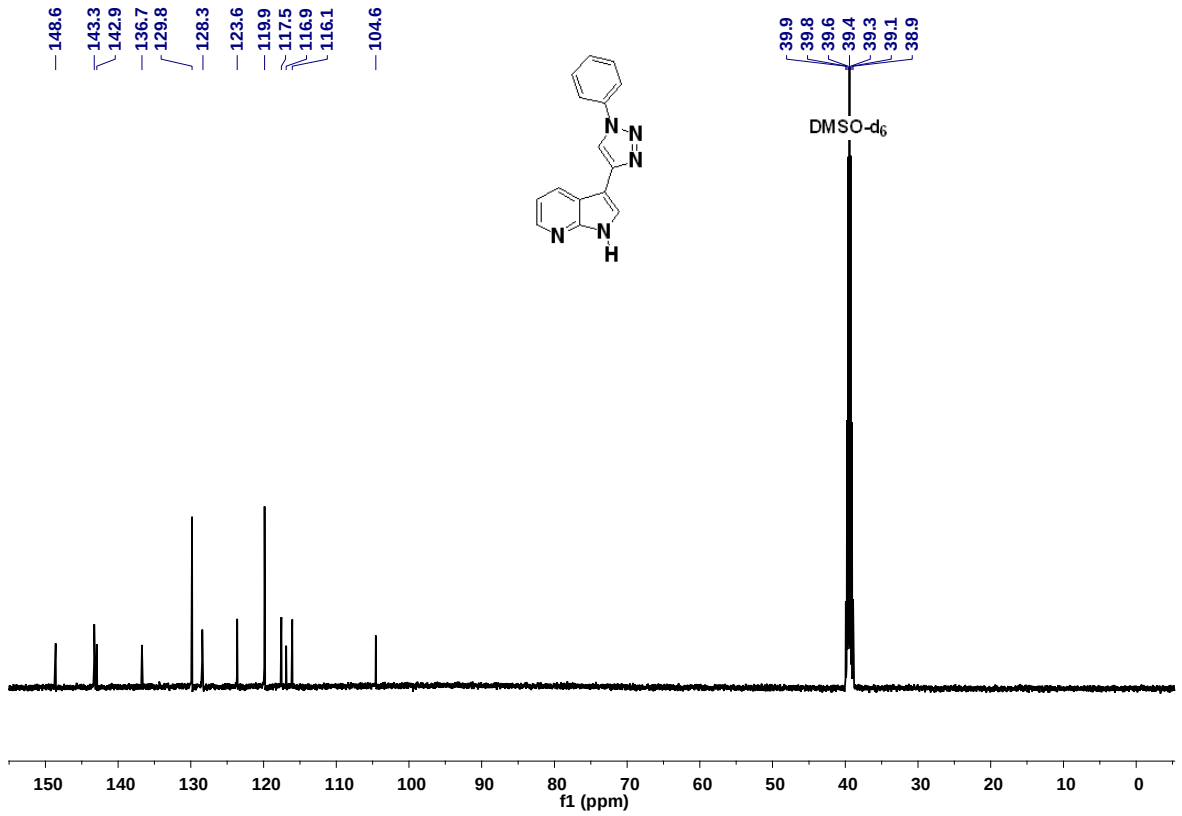
^{13}C NMR of **8f** (15 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).



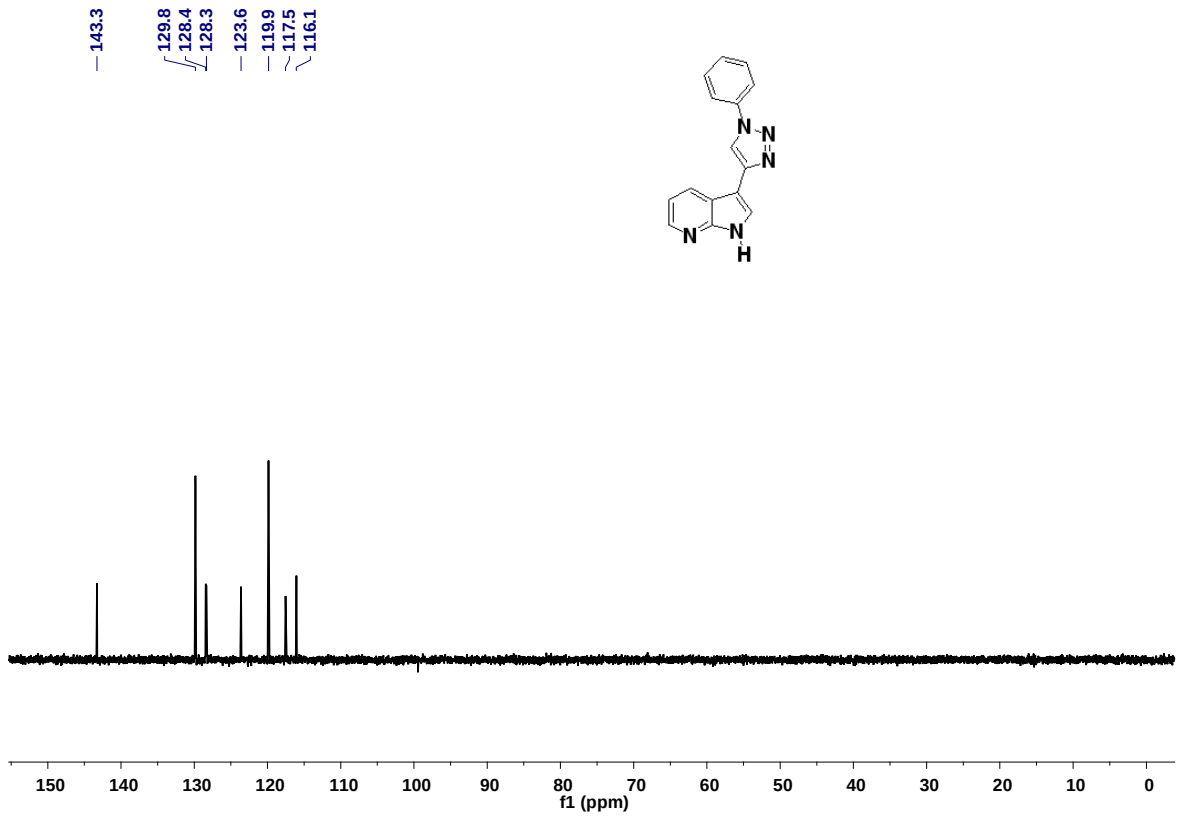
^{13}C DEPT 135-NMR of **8f** (15 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).



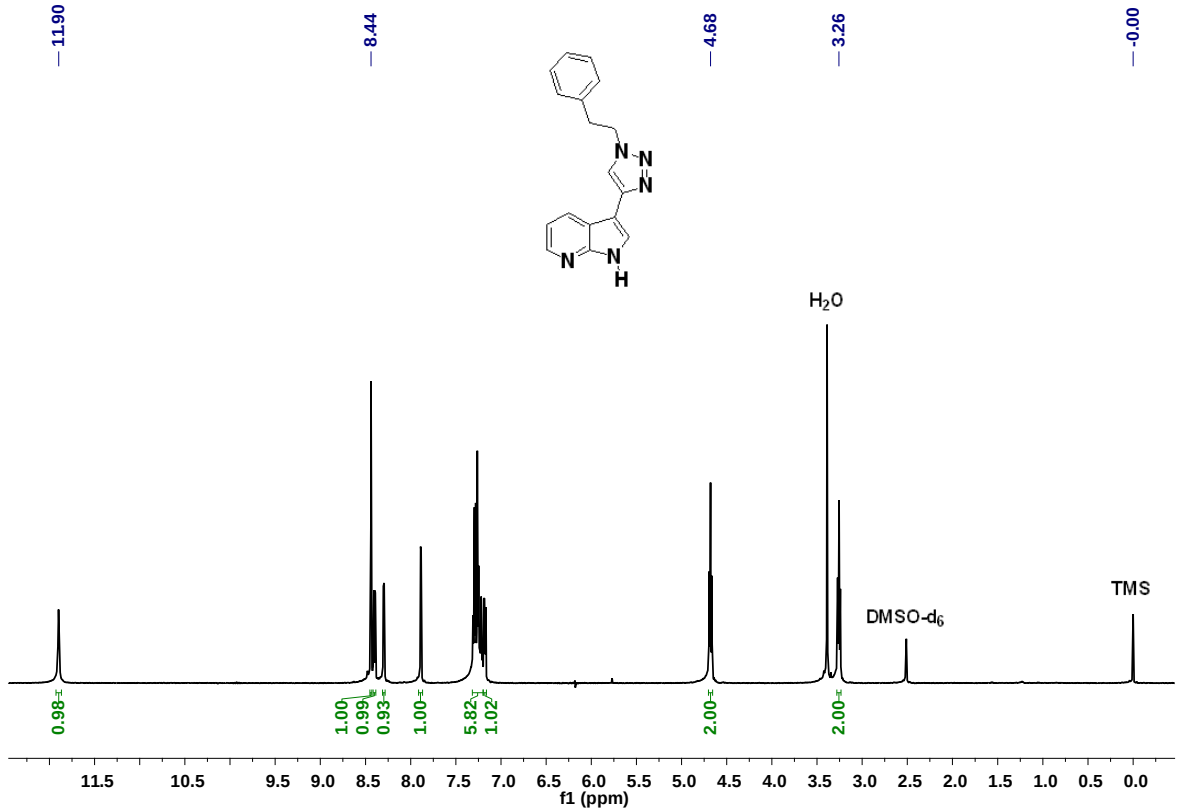
^{1}H NMR of **8g** (20 mg) in 0.7 mL DMSO-d_6 at 297 K (δ in ppm). *Impurities from residual solvents.



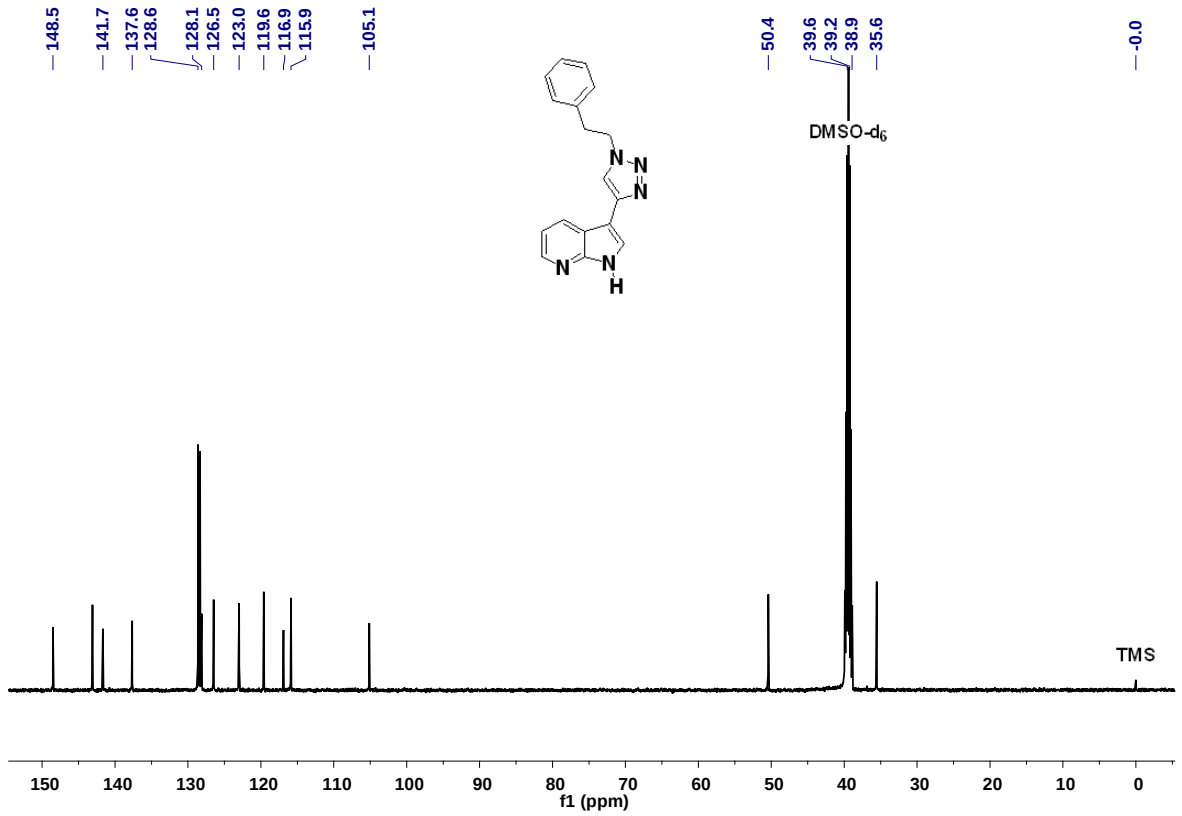
^{13}C NMR of **8g** (20 mg) in 0.7 mL DMSO-d_6 at 297 K (δ in ppm).



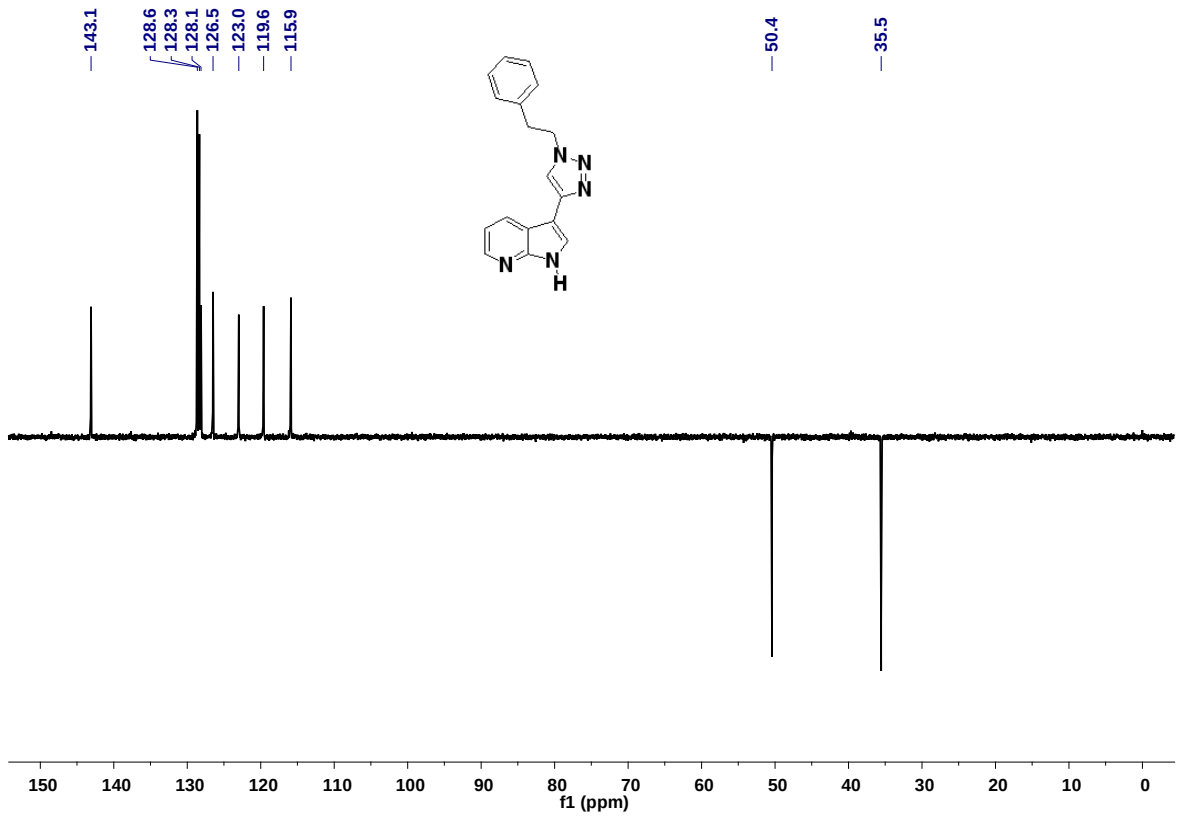
^{13}C DEPT 135-NMR of **8g** (20 mg) in 0.7 mL DMSO-d_6 at 297 K (δ in ppm).



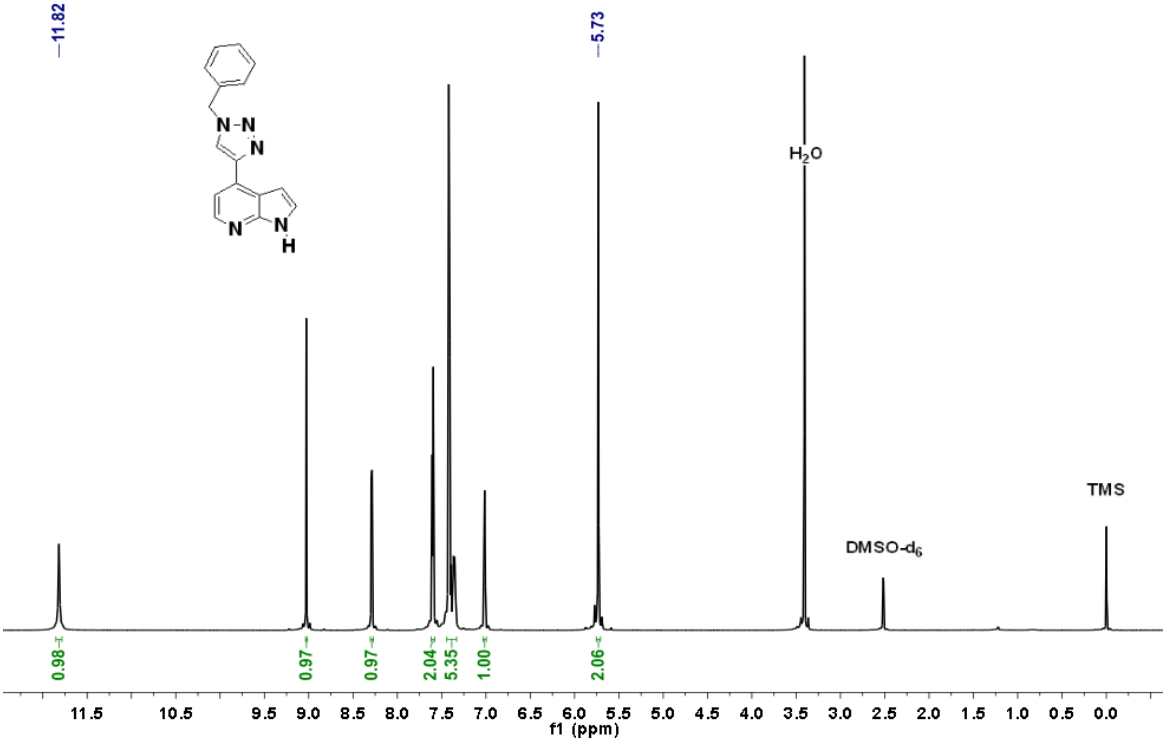
^{1}H NMR of **8r** (20 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).



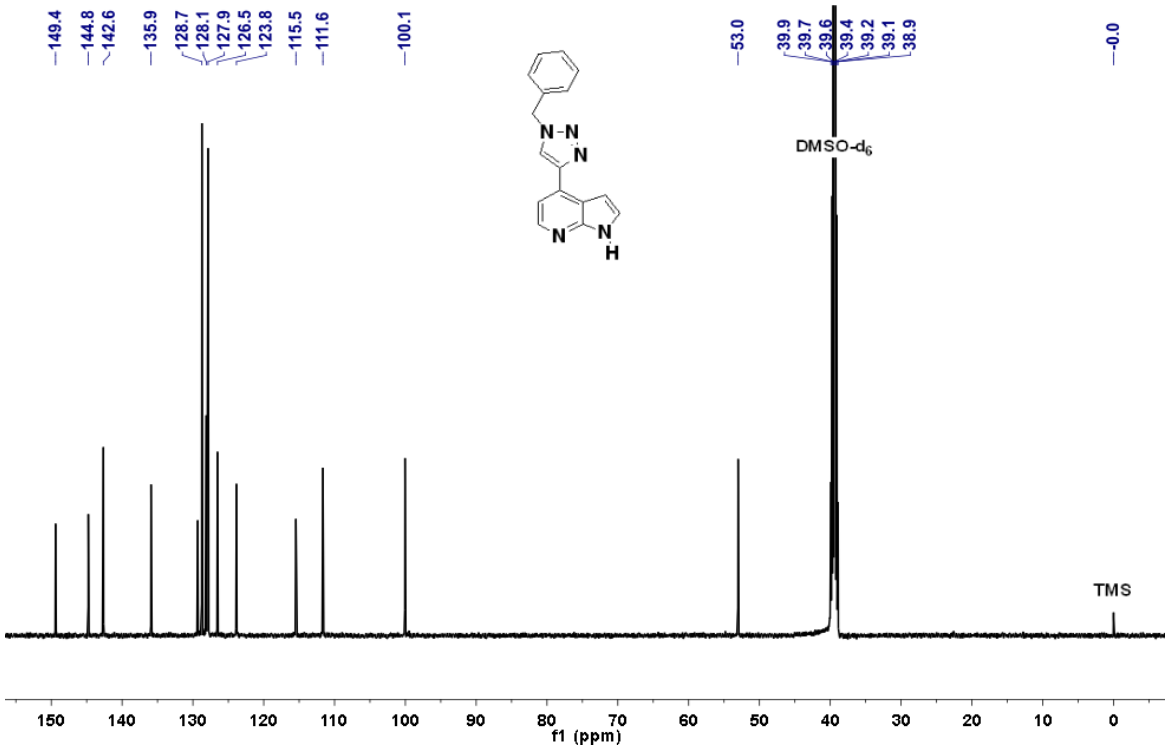
^{13}C NMR of **8r** (20 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).



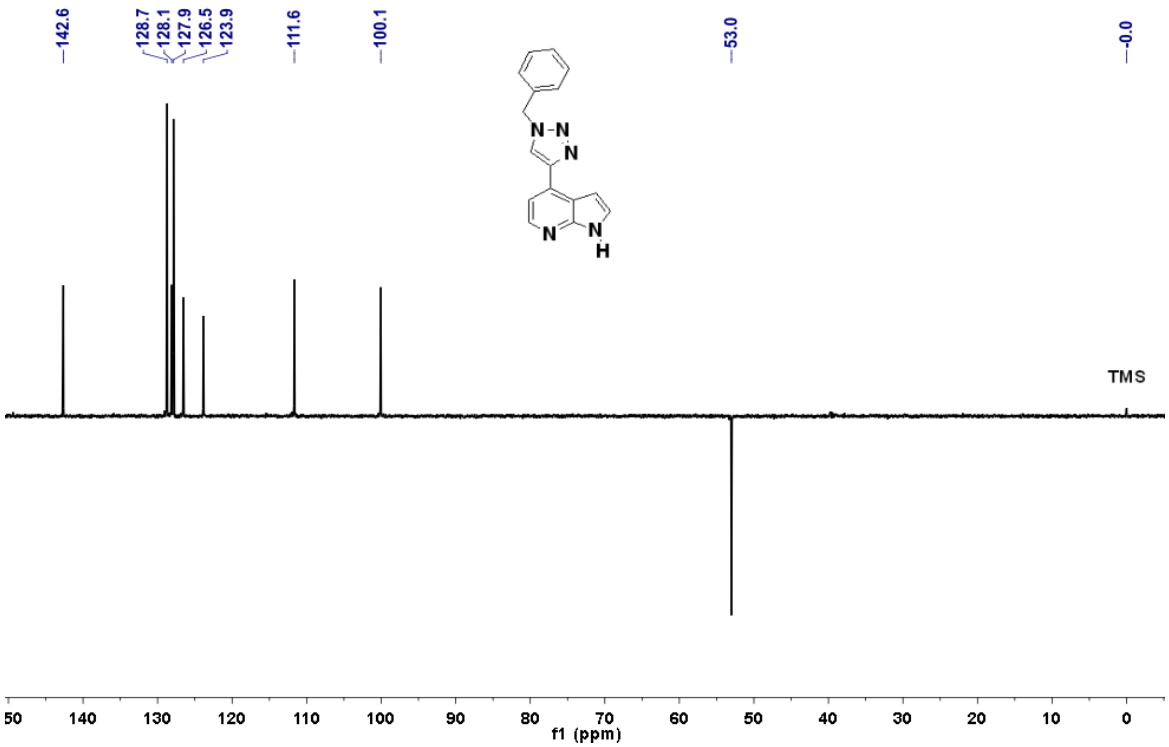
^{13}C DEPT 135-NMR of **8r** (20 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).



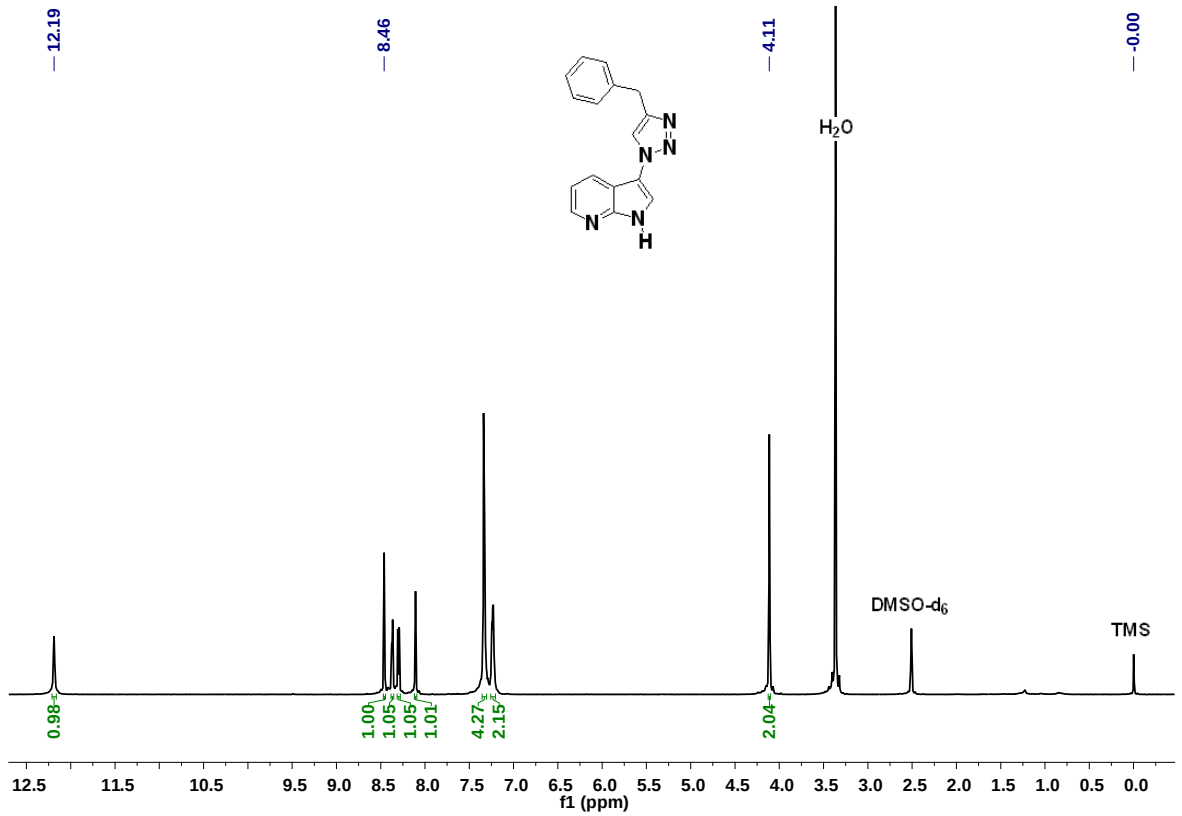
^{1}H NMR of **9a** (15 mg) in 0.7 mL DMSO-d_6 at 295 K (δ in ppm).



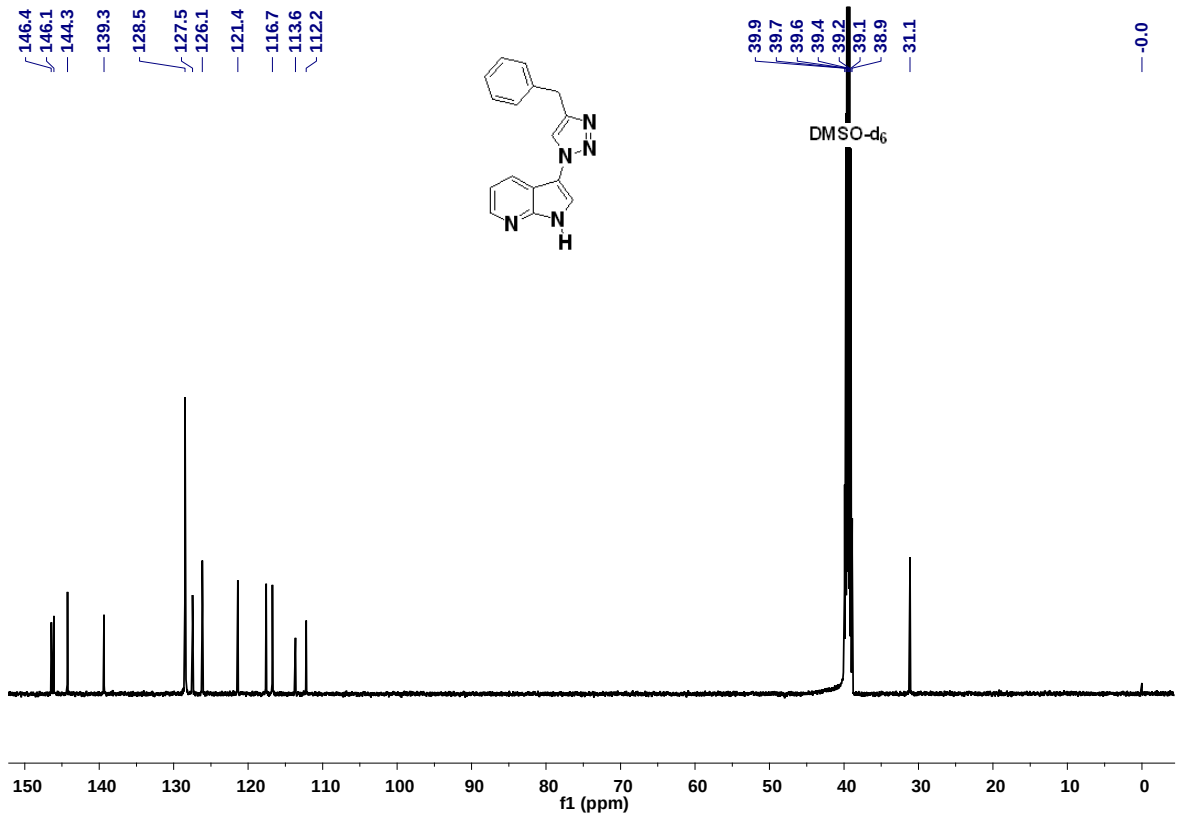
^{13}C NMR of **9a** (15 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).



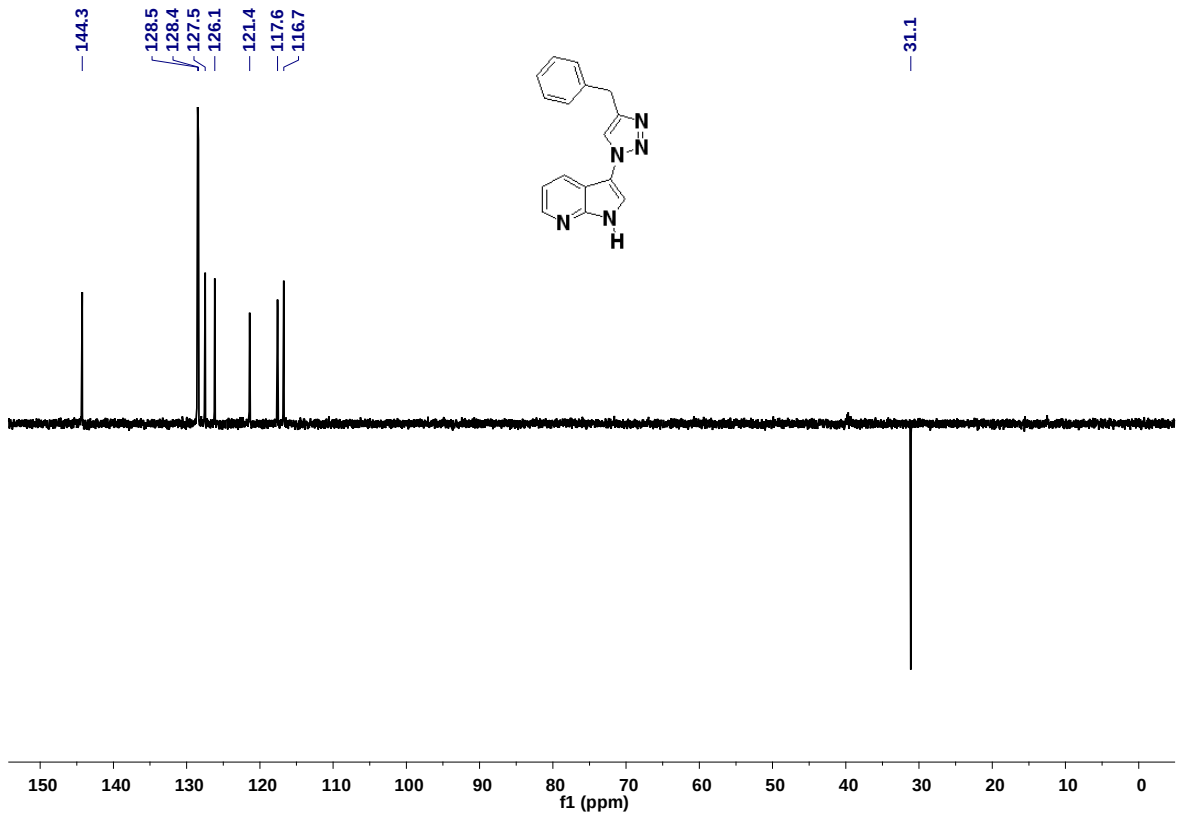
^{13}C DEPT 135-NMR of **9a** (15 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).



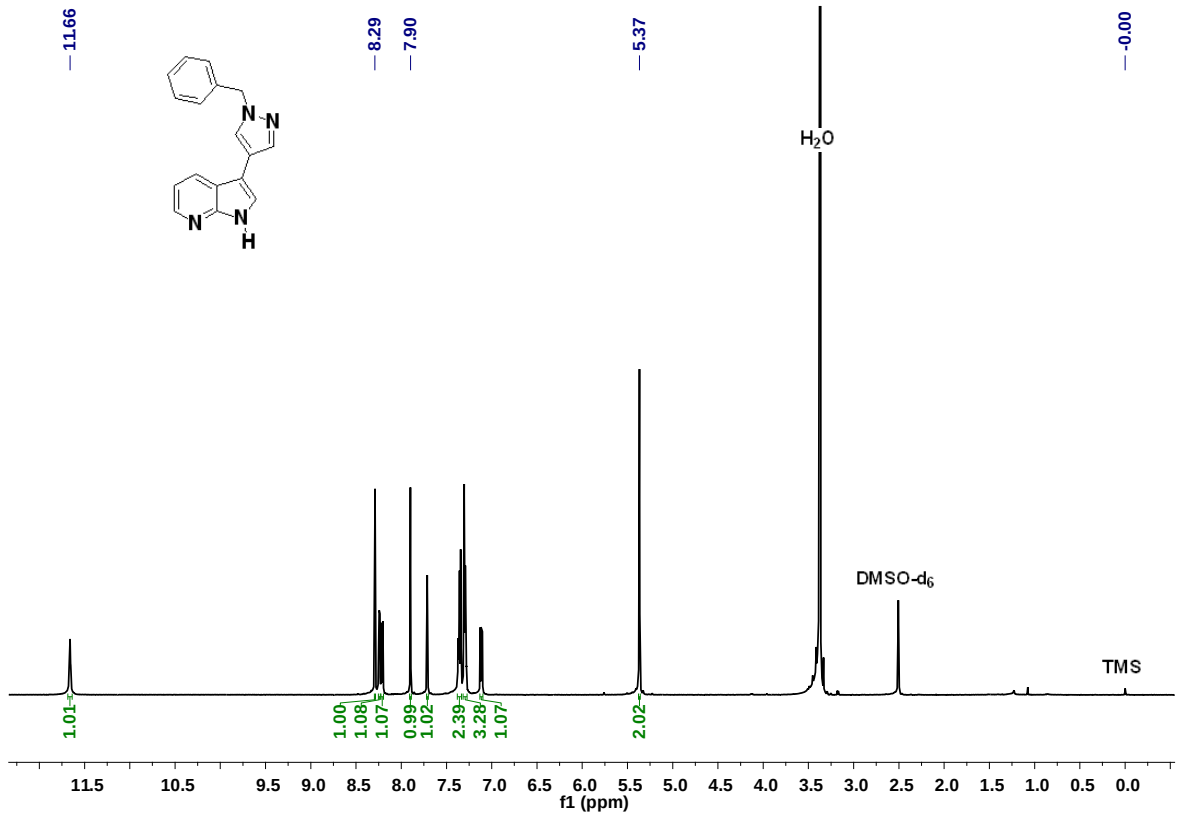
^{1}H NMR of **10** (15 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).



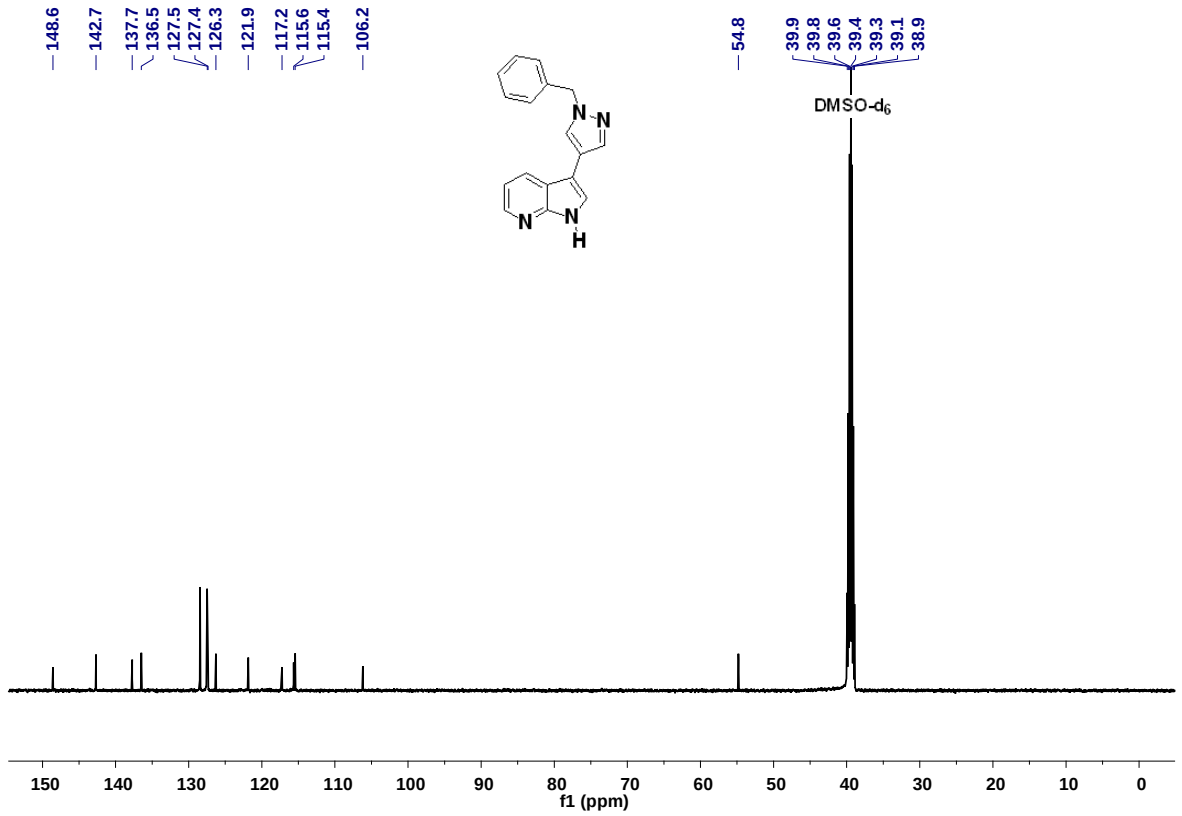
^{13}C NMR of **10** (15 mg) in 0.7 mL DMSO-d_6 at 297 K (δ in ppm).



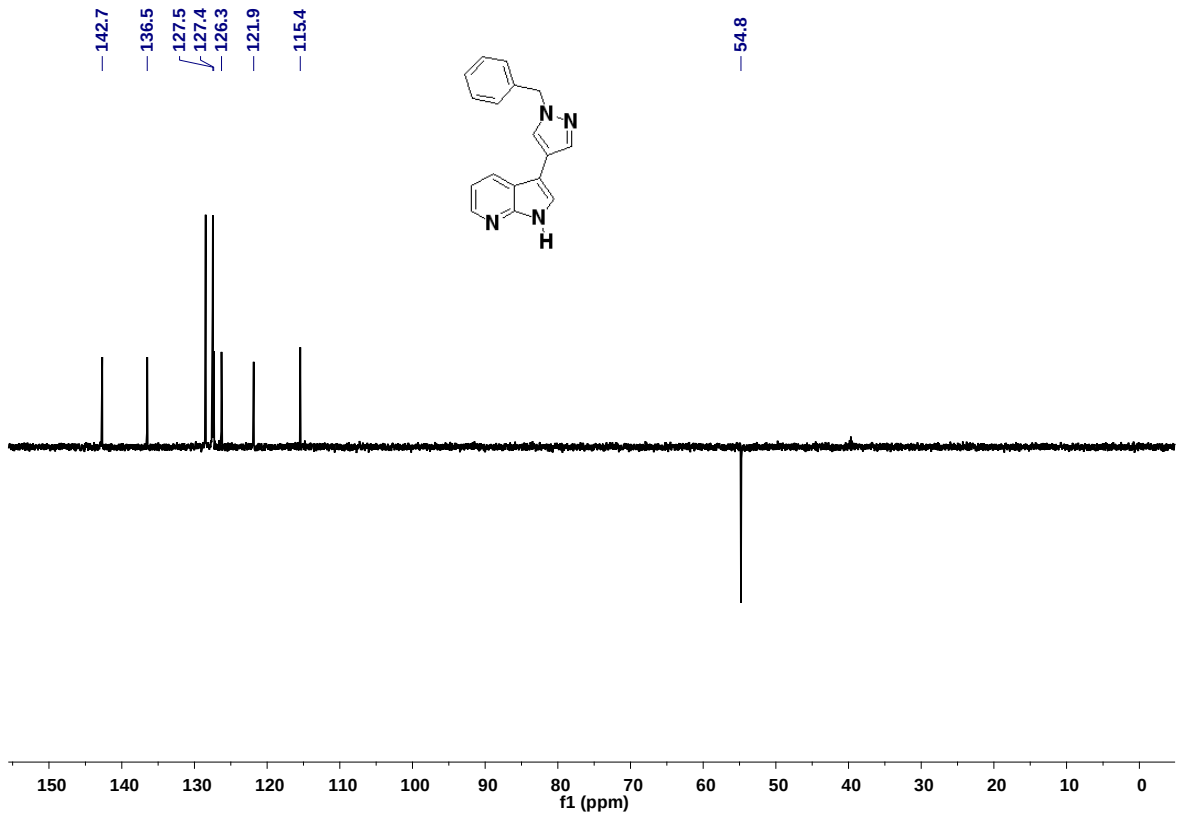
^{13}C DEPT 135-NMR of **10** (15 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).



^{1}H NMR of **11** (15 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).



^{13}C NMR of **11** (15 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).

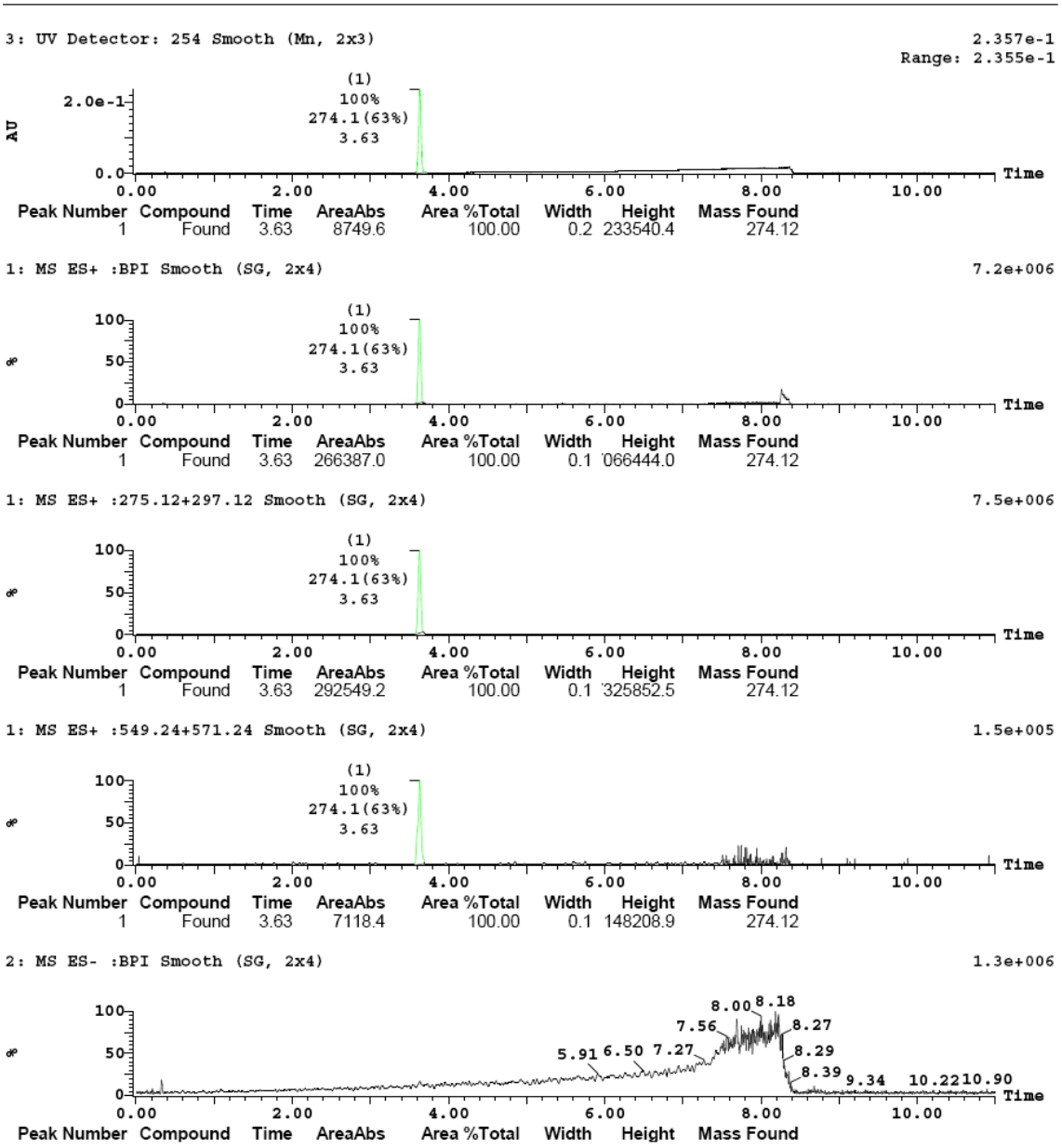


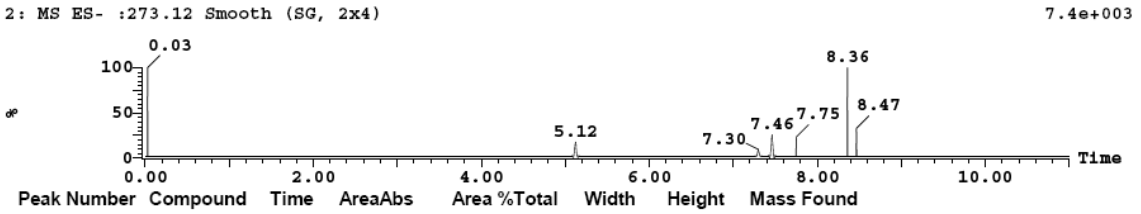
^{13}C DEPT 135-NMR of **11** (15 mg) in 0.7 mL DMSO-d_6 at 296 K (δ in ppm).

8. Appendix

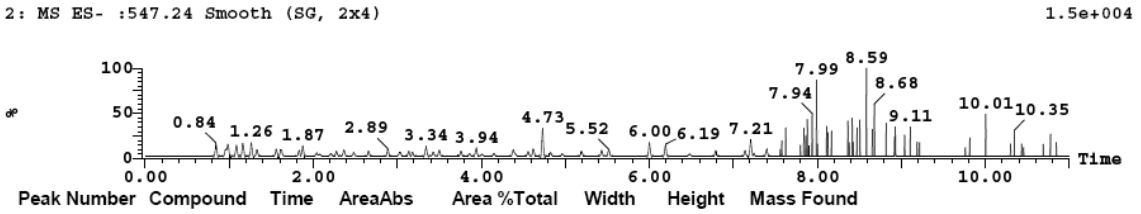
8.1. HT-LC-MS Spectra and UV purity of the obtained compounds 8a-s, 9a-b, 10, and 11

HT-LC-MS Spectrum (SOP 2200) of **8a**. UV purity: 100 %

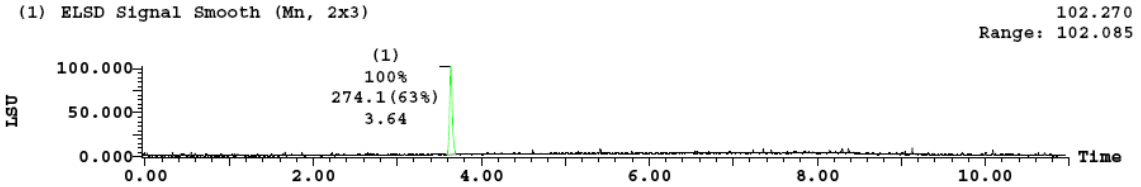




Peak Number | Compound | Time | AreaAbs | Area %Total | Width | Height | Mass Found

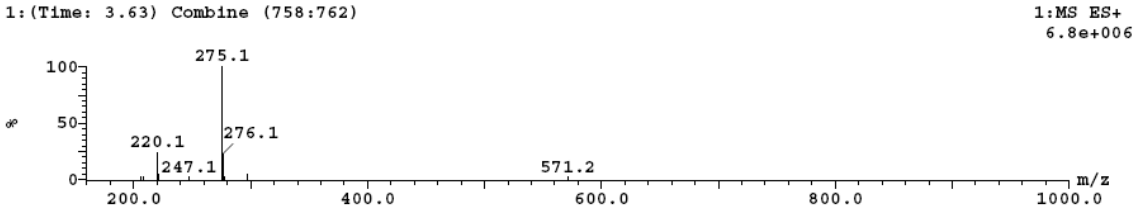


Peak Number | Compound | Time | AreaAbs | Area %Total | Width | Height | Mass Found

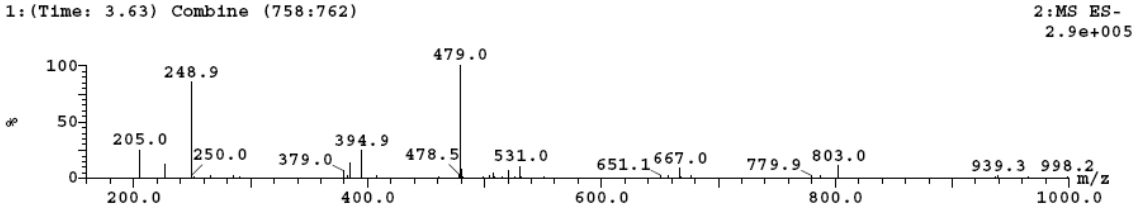


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
1	Found	3.64	3717.6	100.00	99559.7	274.12

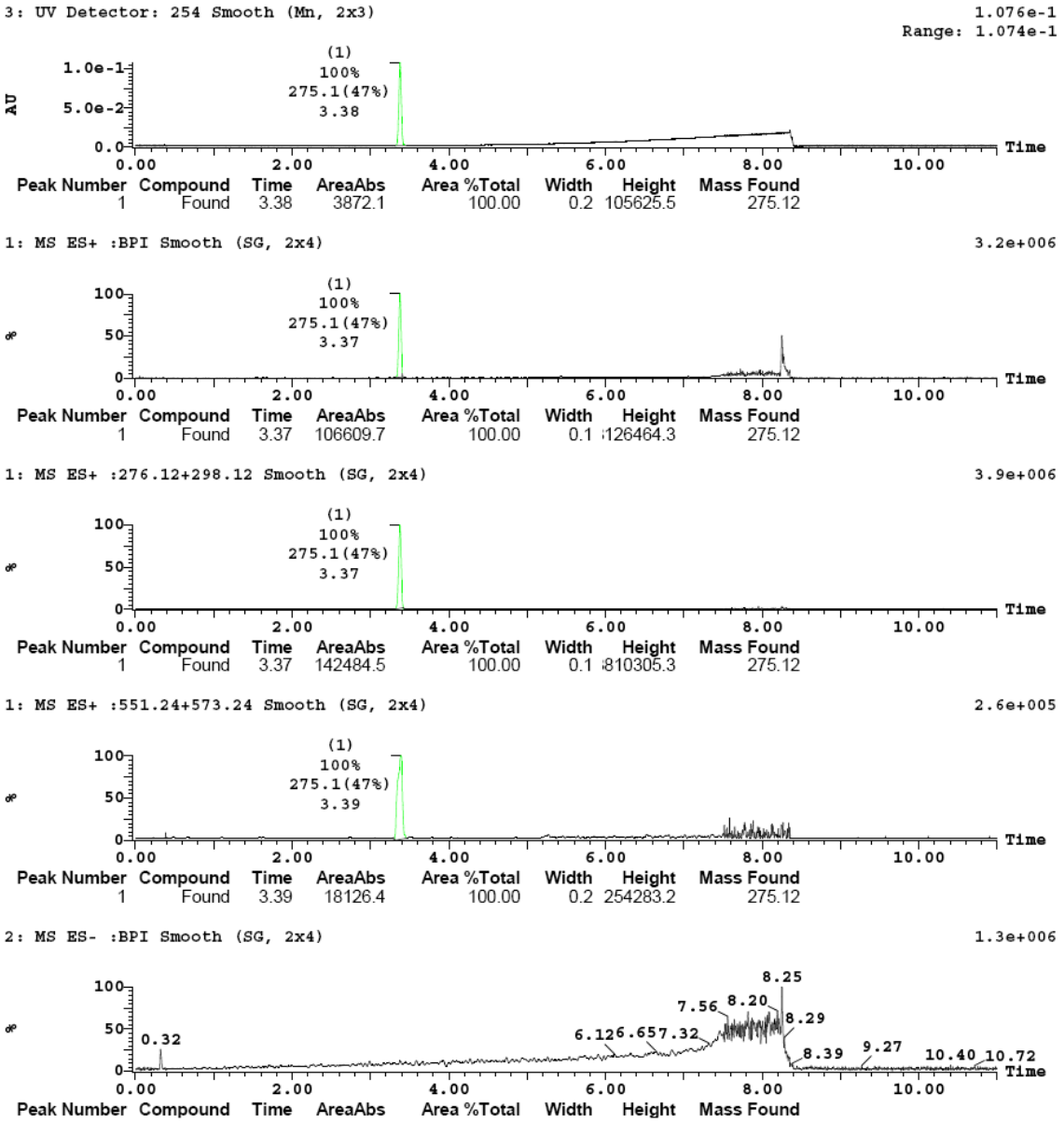
Peak ID	Compound	Time	Mass Found
1	Found	3.63	274.12

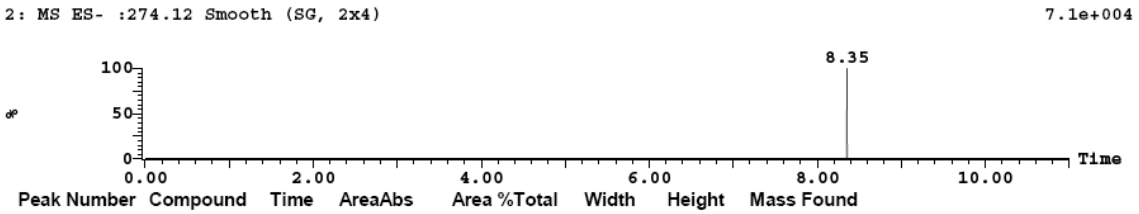


Peak ID	Compound	Time	Mass Found
1		3.63	

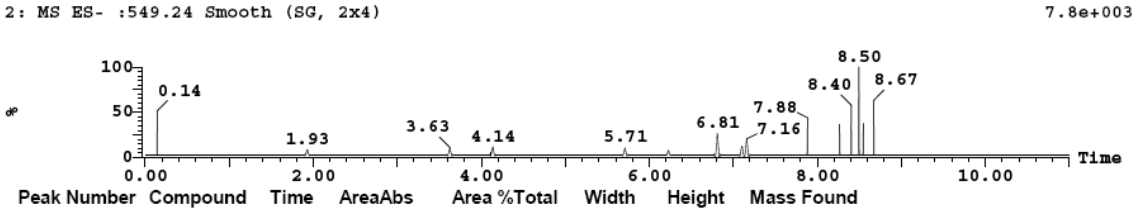


HT-LC-MS Spectrum (SOP 2200) of **8b**. UV purity: 100 %

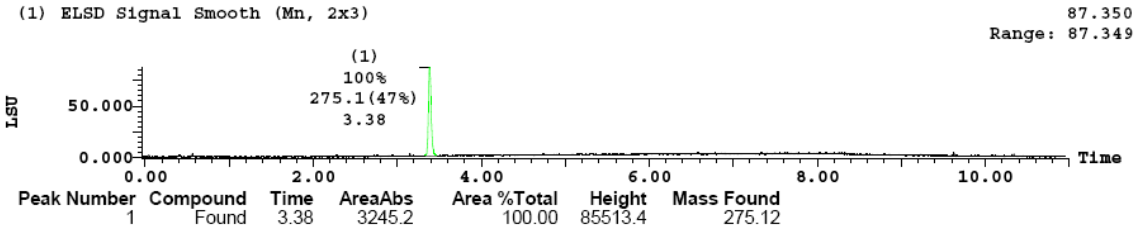




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

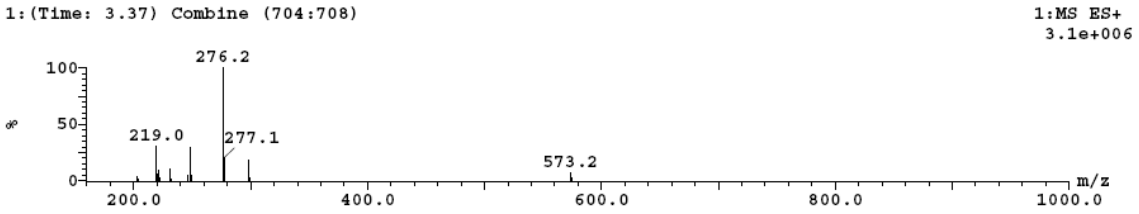


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

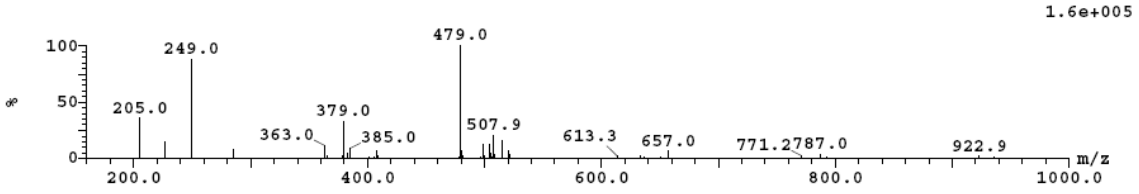


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
1	Found	3.38	3245.2	100.00	85513.4	275.12

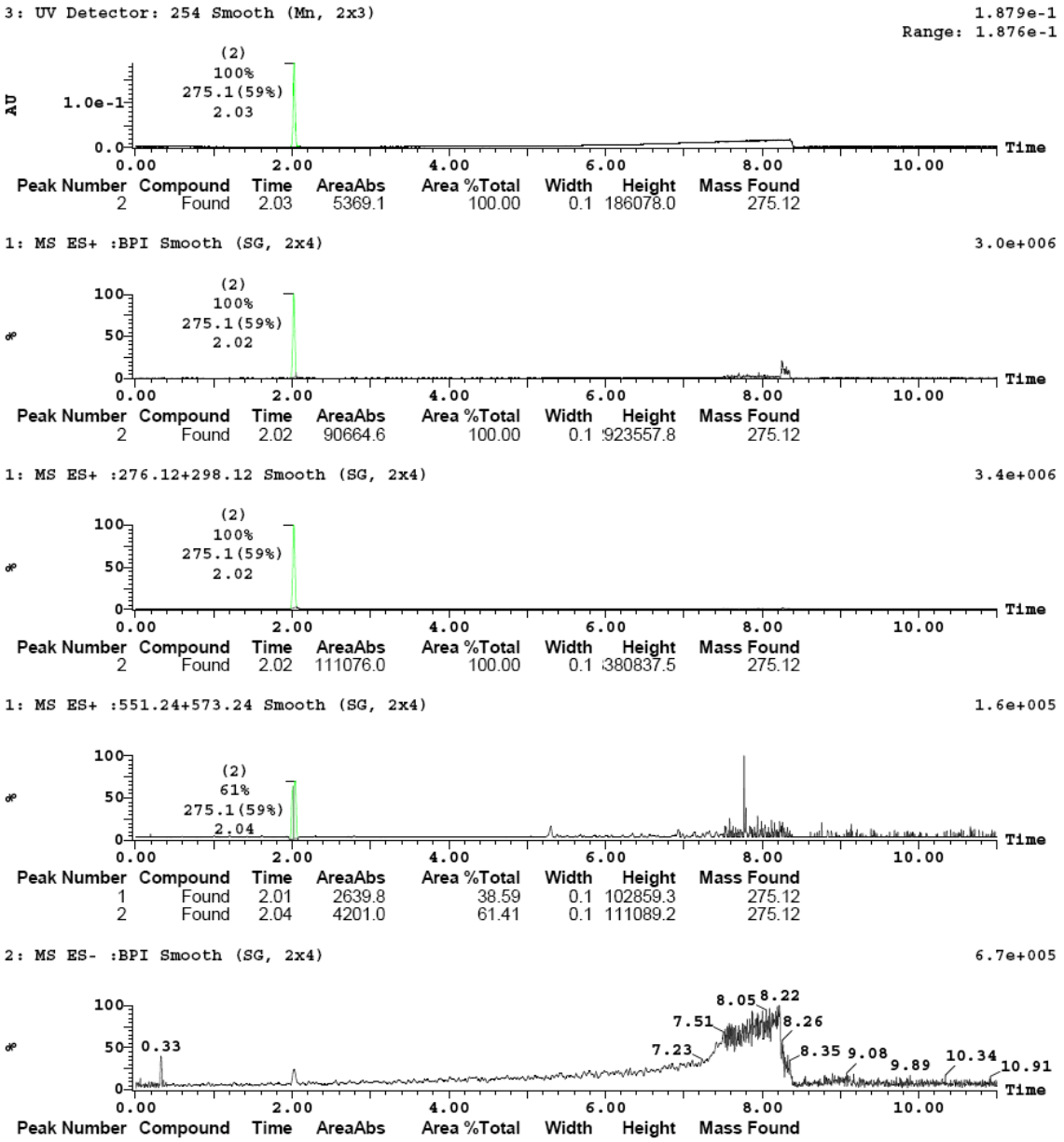
Peak ID	Compound	Time	Mass Found
1	Found	3.37	275.12

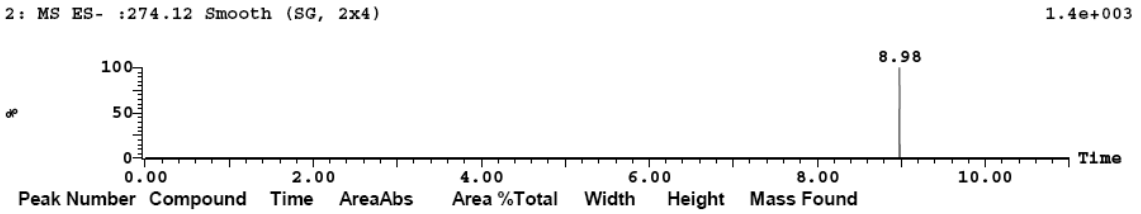


Peak ID	Compound	Time	Mass Found
1		3.37	

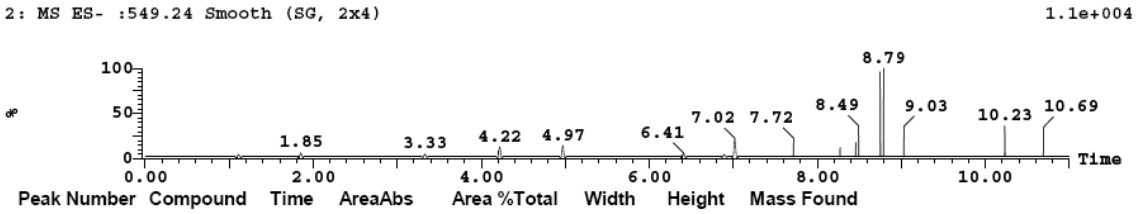


HT-LC-MS Spectrum (SOP 2200) of **8c**. UV purity: 100 %

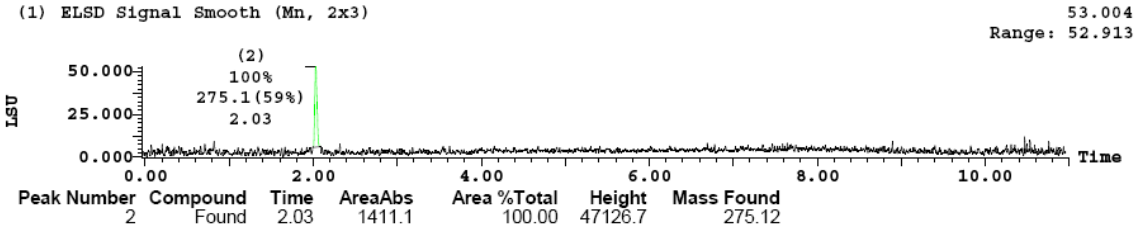




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

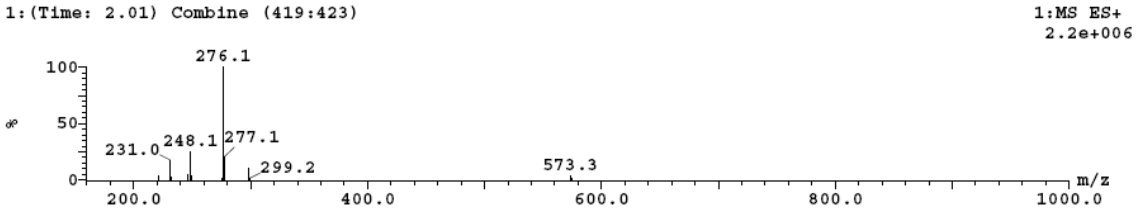


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found



Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
2	Found	2.03	1411.1	100.00	47126.7	275.12

Peak ID	Compound	Time	Mass Found
1	Found	2.01	275.12



Peak ID	Compound	Time	Mass Found
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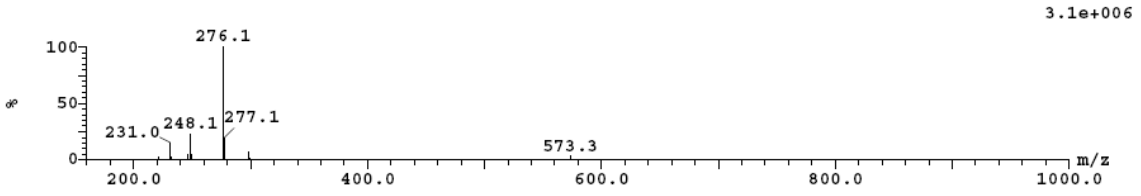
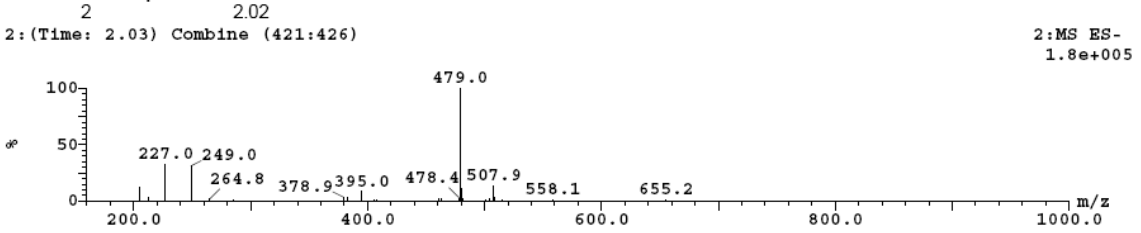
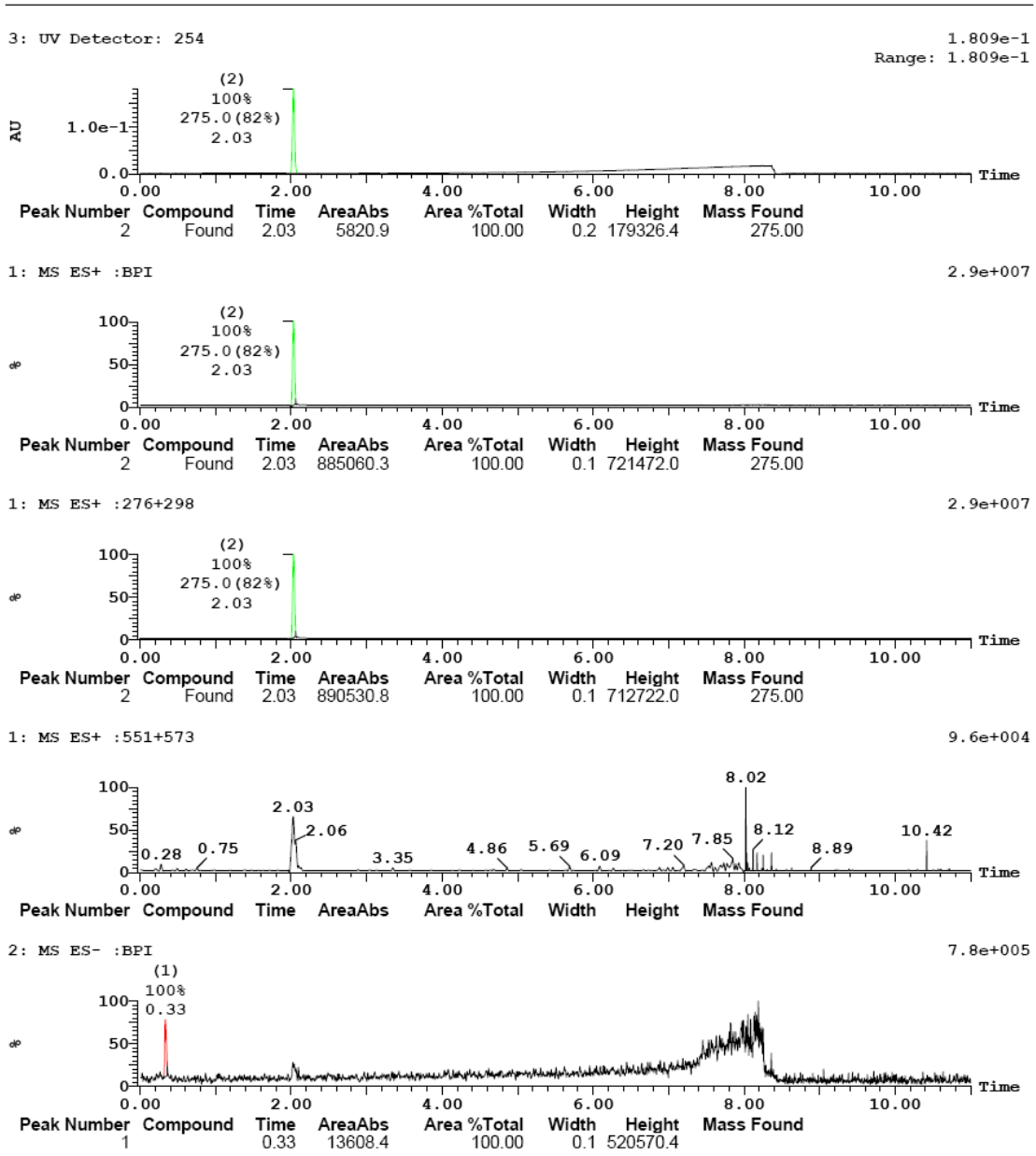
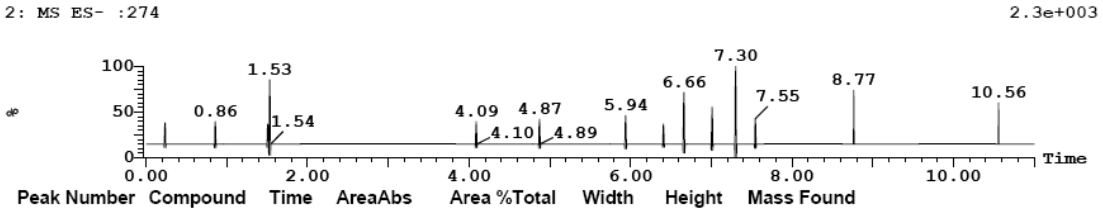


Peak ID	Compound	Time	Mass Found
2		2.02	

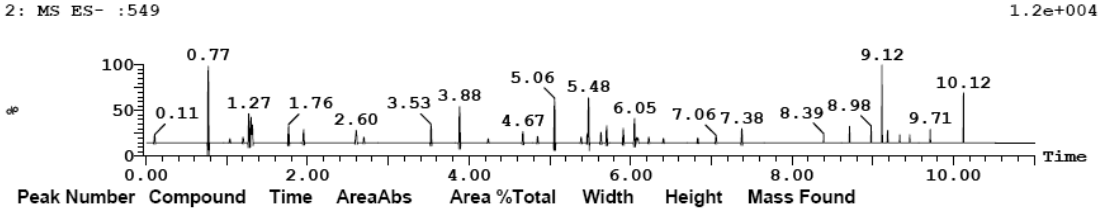


HT-LC-MS Spectrum (SOP 2200) of **8d**. UV purity: 100 %

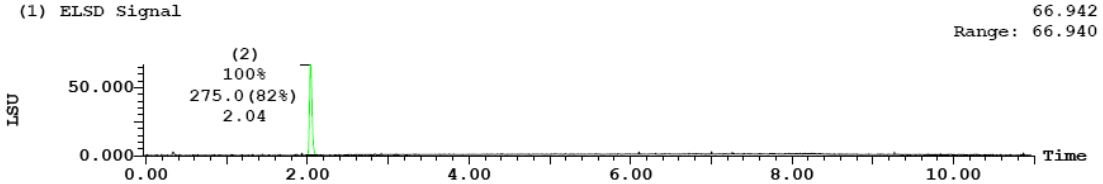




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

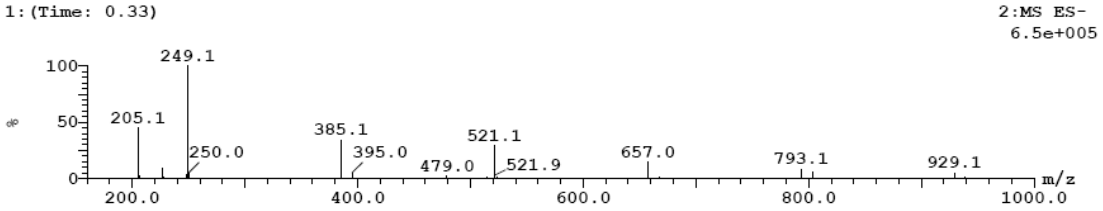


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

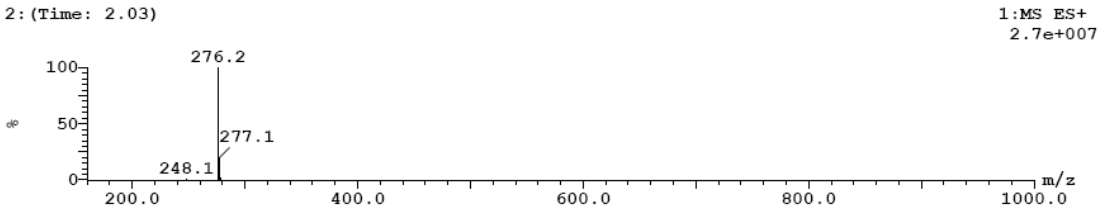


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
2	Found	2.04	2367.7	100.00	66394.2	275.00

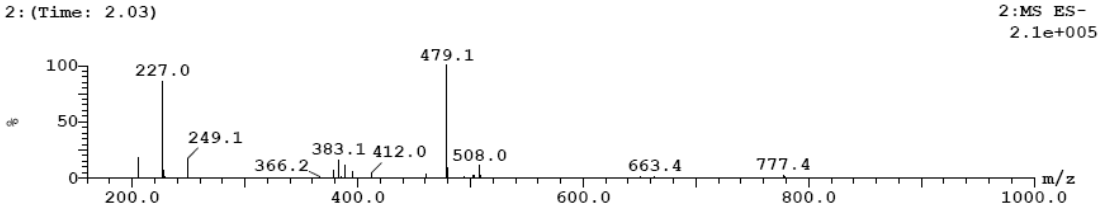
Peak ID	Compound	Time	Mass Found
1		0.33	



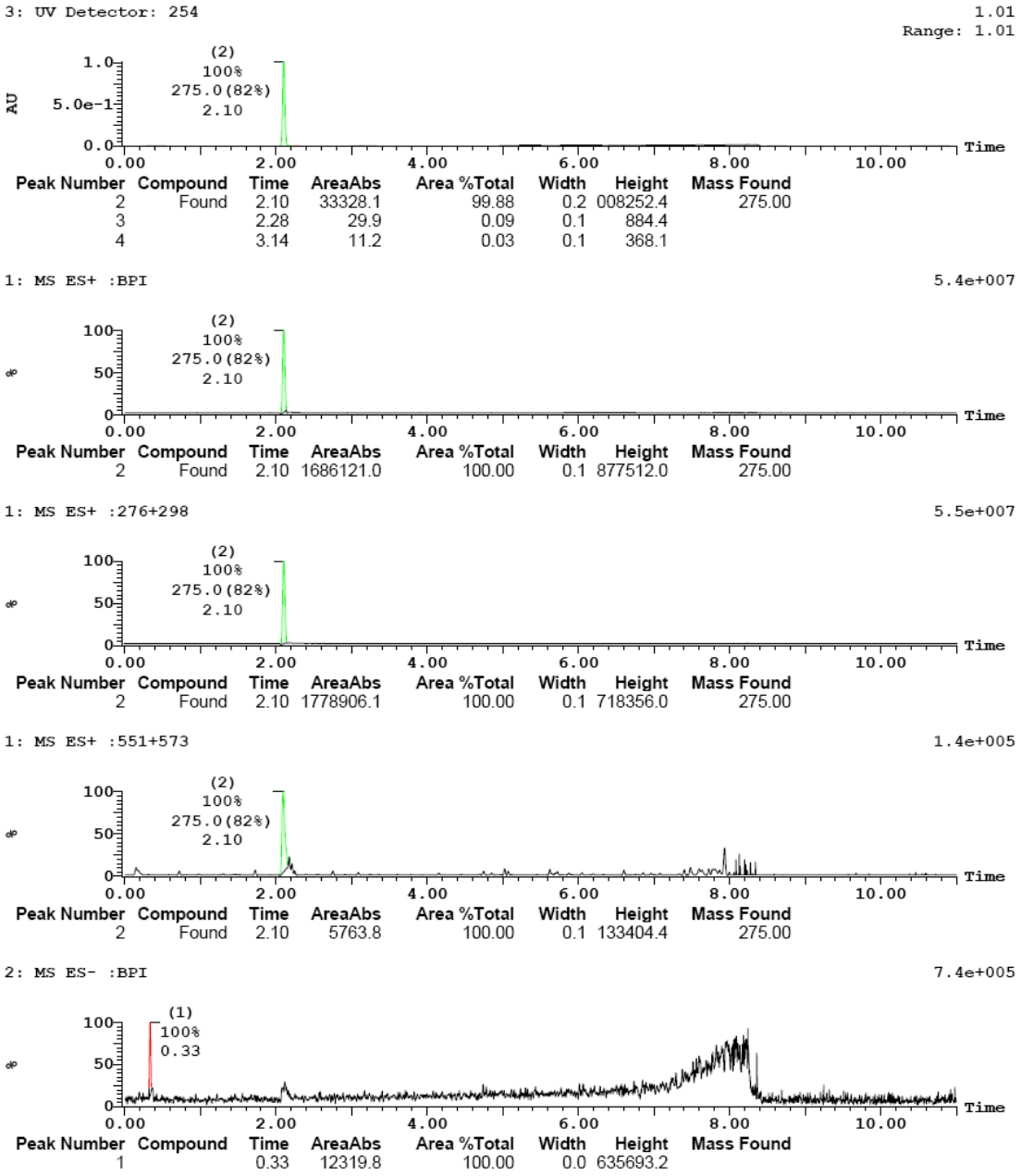
Peak ID	Compound	Time	Mass Found
2	Found	2.03	275.00

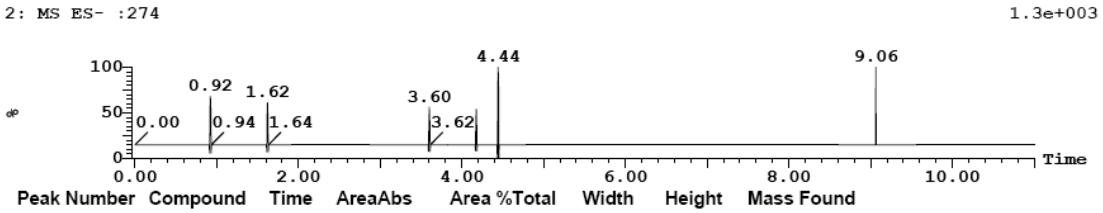


Peak ID	Compound	Time	Mass Found
2		2.03	

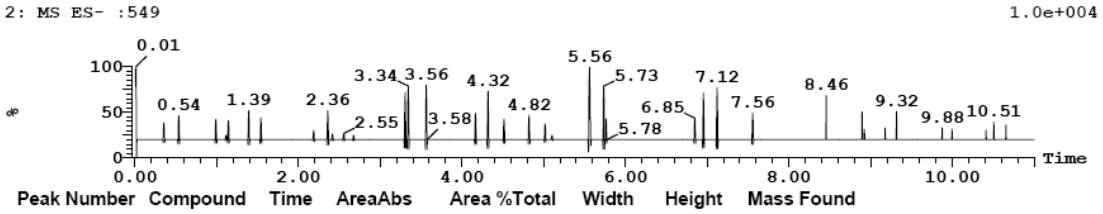


HT-LC-MS Spectrum (SOP 2200) of **8e**. UV purity: 99.9 %

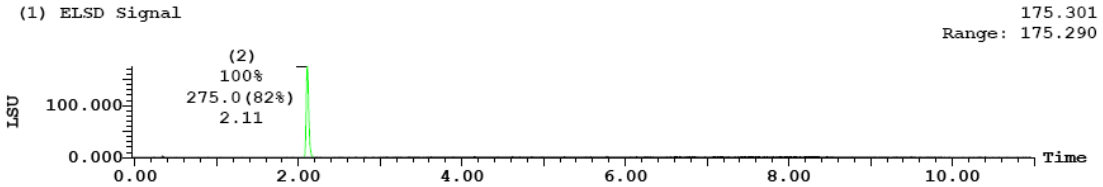




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

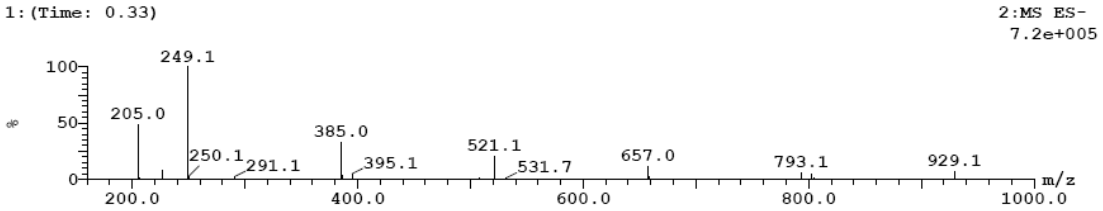


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

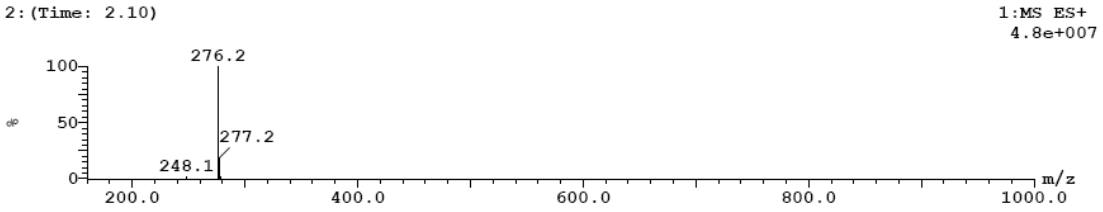


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
2	Found	2.11	6252.6	100.00	174913.5	275.00

Peak ID	Compound	Time	Mass Found
1		0.33	

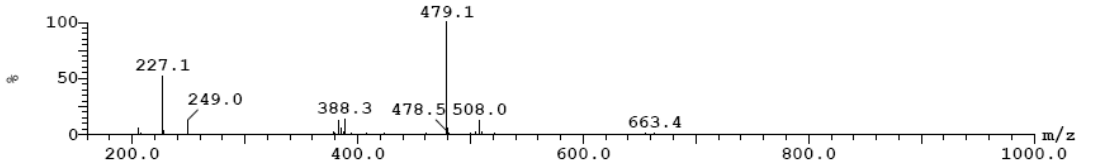


Peak ID	Compound	Time	Mass Found
2	Found	2.10	275.00



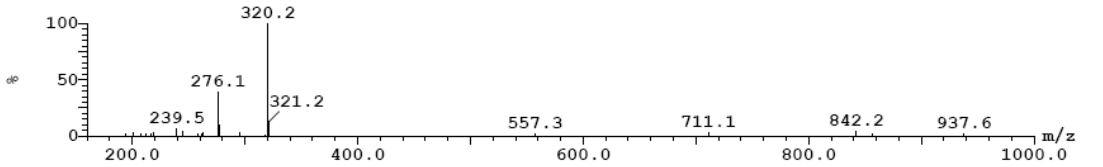
Peak ID	Compound	Time	Mass Found
2		2.10	

2:(Time: 2.11) 2:MS ES- 2.4e+005



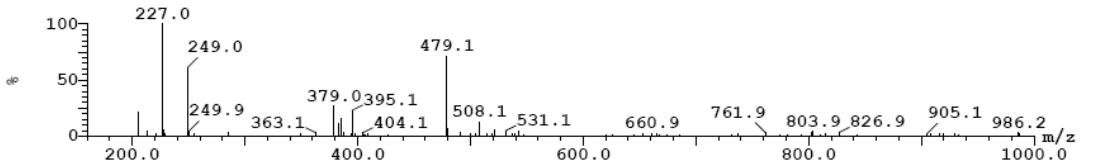
Peak ID	Compound	Time	Mass Found
3		2.28	

3:(Time: 2.28) 1:MS ES+ 1.8e+005



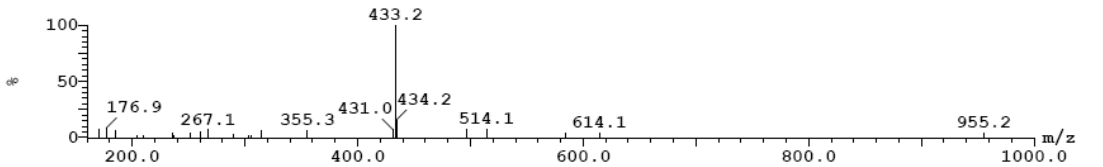
Peak ID	Compound	Time	Mass Found
3		2.28	

3:(Time: 2.28) 2:MS ES- 9.1e+004



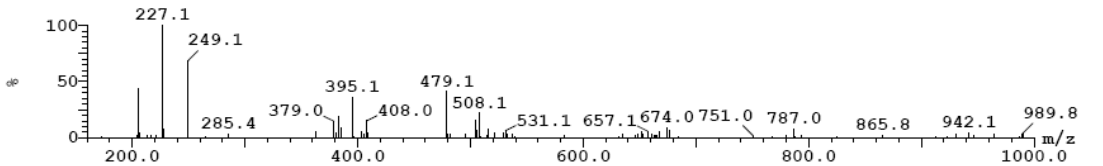
Peak ID	Compound	Time	Mass Found
4		3.14	

4:(Time: 3.14) 1:MS ES+ 7.8e+004

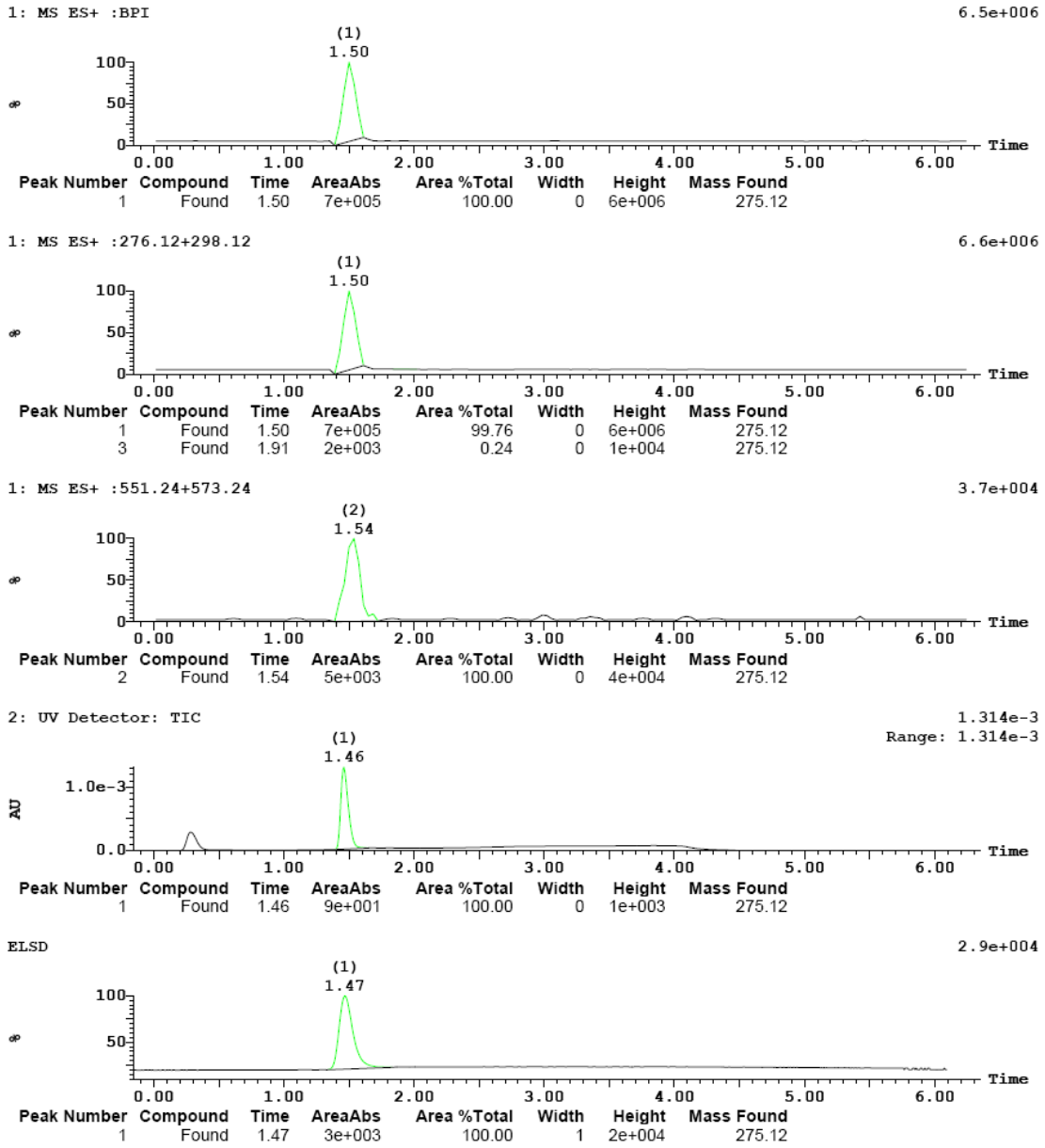


Peak ID	Compound	Time	Mass Found
4		3.14	

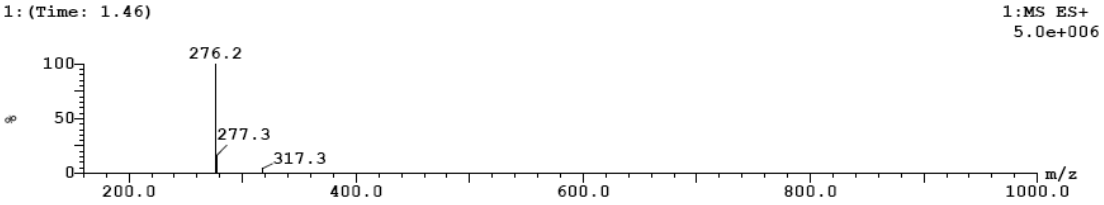
4:(Time: 3.14) 2:MS ES- 9.4e+004



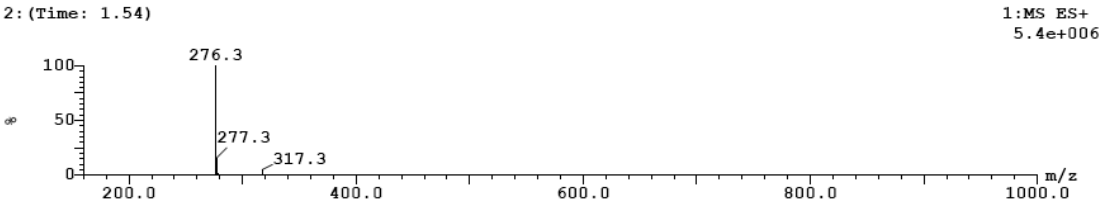
HT-LC-MS Spectrum (SOP 2222) of **8f**. UV purity: 100 %



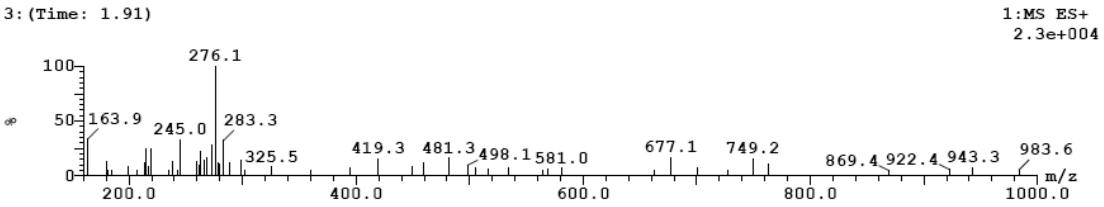
Peak ID	Compound	Time	Mass Found
1	Found	1.50	275.12



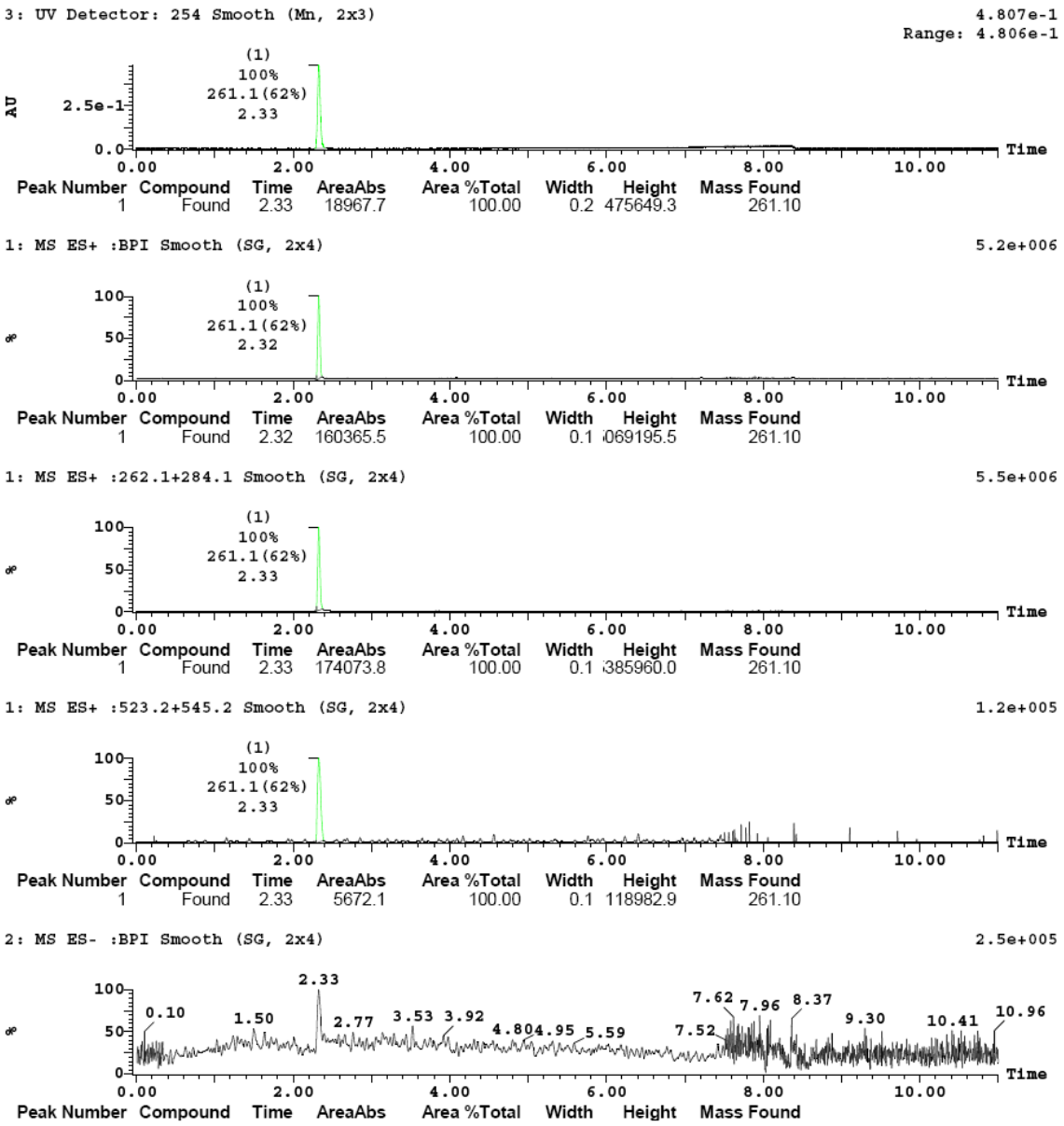
Peak ID	Compound	Time	Mass Found
2	Found	1.54	275.12

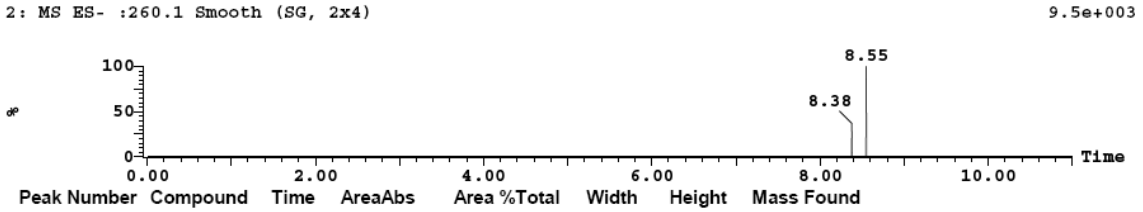


Peak ID	Compound	Time	Mass Found
3	Found	1.91	275.12

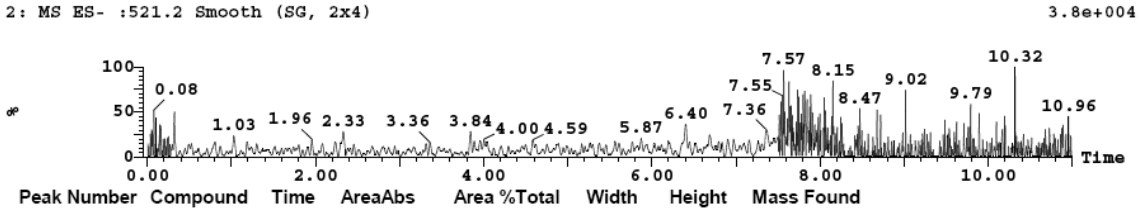


HT-LC-MS Spectrum (SOP 2200) of **8g**. UV purity: 100 %

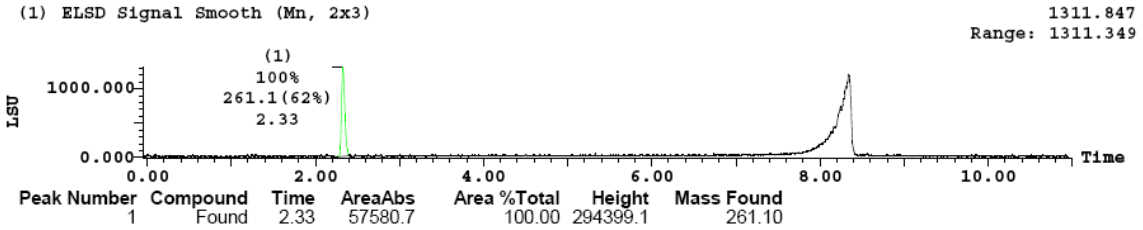




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

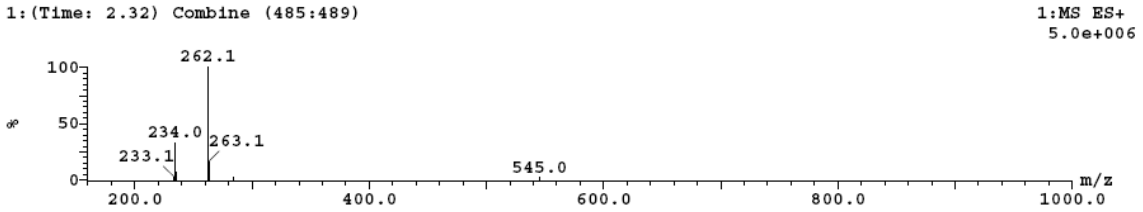


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

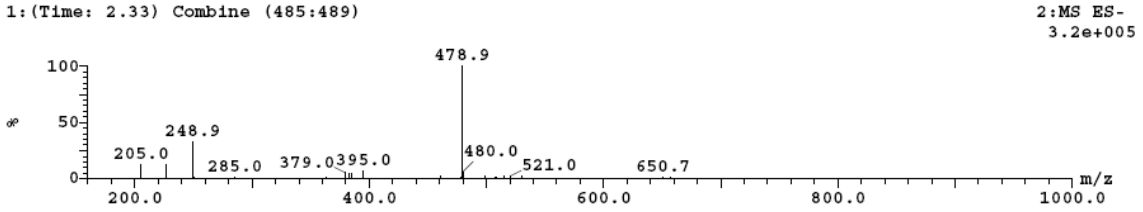


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
1	Found	2.33	57580.7	100.00	294399.1	261.10

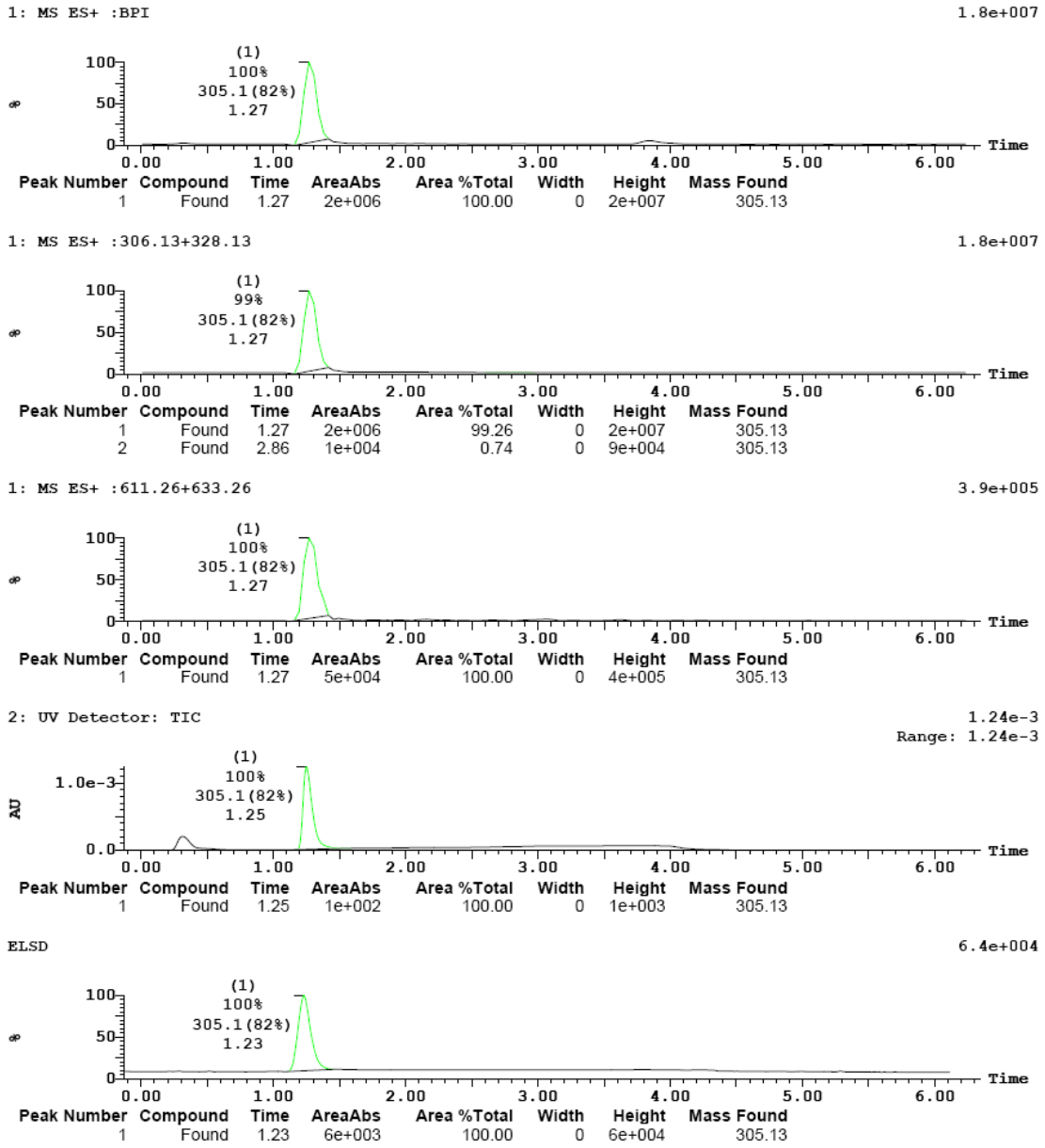
Peak ID	Compound	Time	Mass Found
1	Found	2.32	261.10



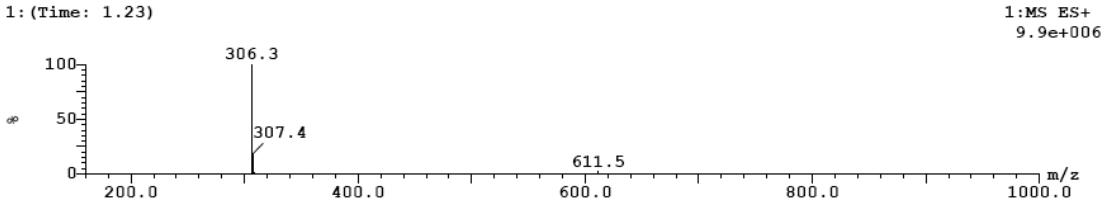
Peak ID	Compound	Time	Mass Found
1		2.32	



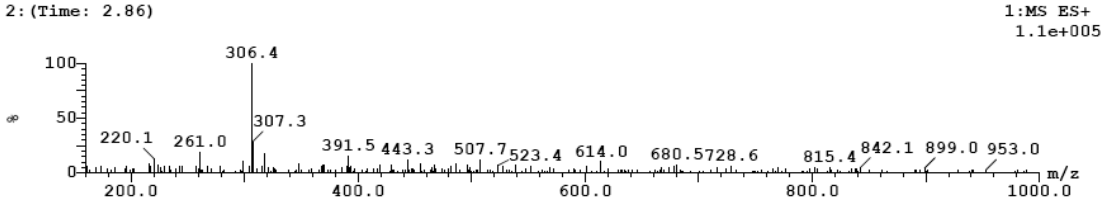
HT-LC-MS Spectrum (SOP 2222) of **8h**. UV purity: 100 %



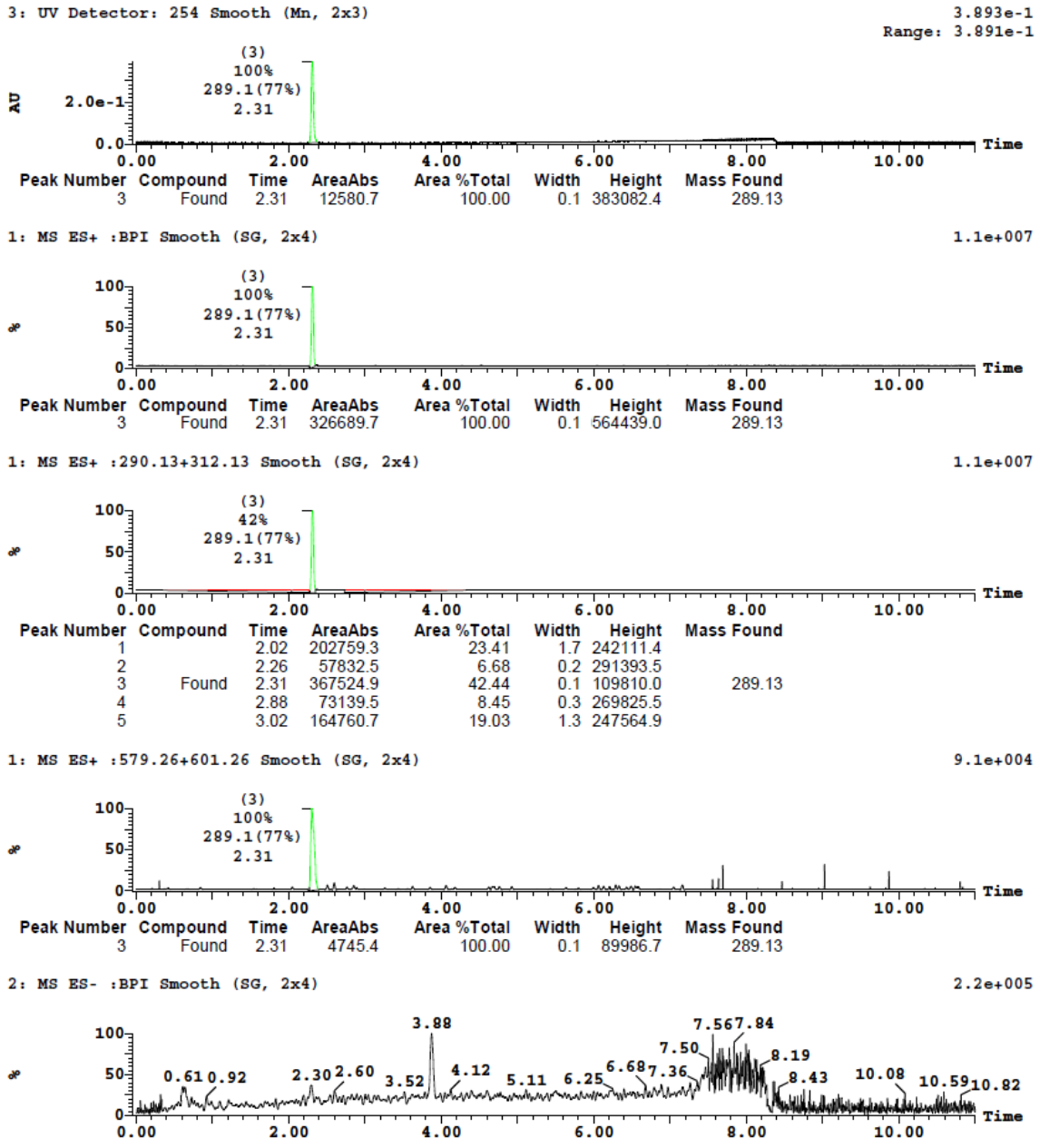
Peak ID	Compound	Time	Mass Found
1	Found	1.27	305.13

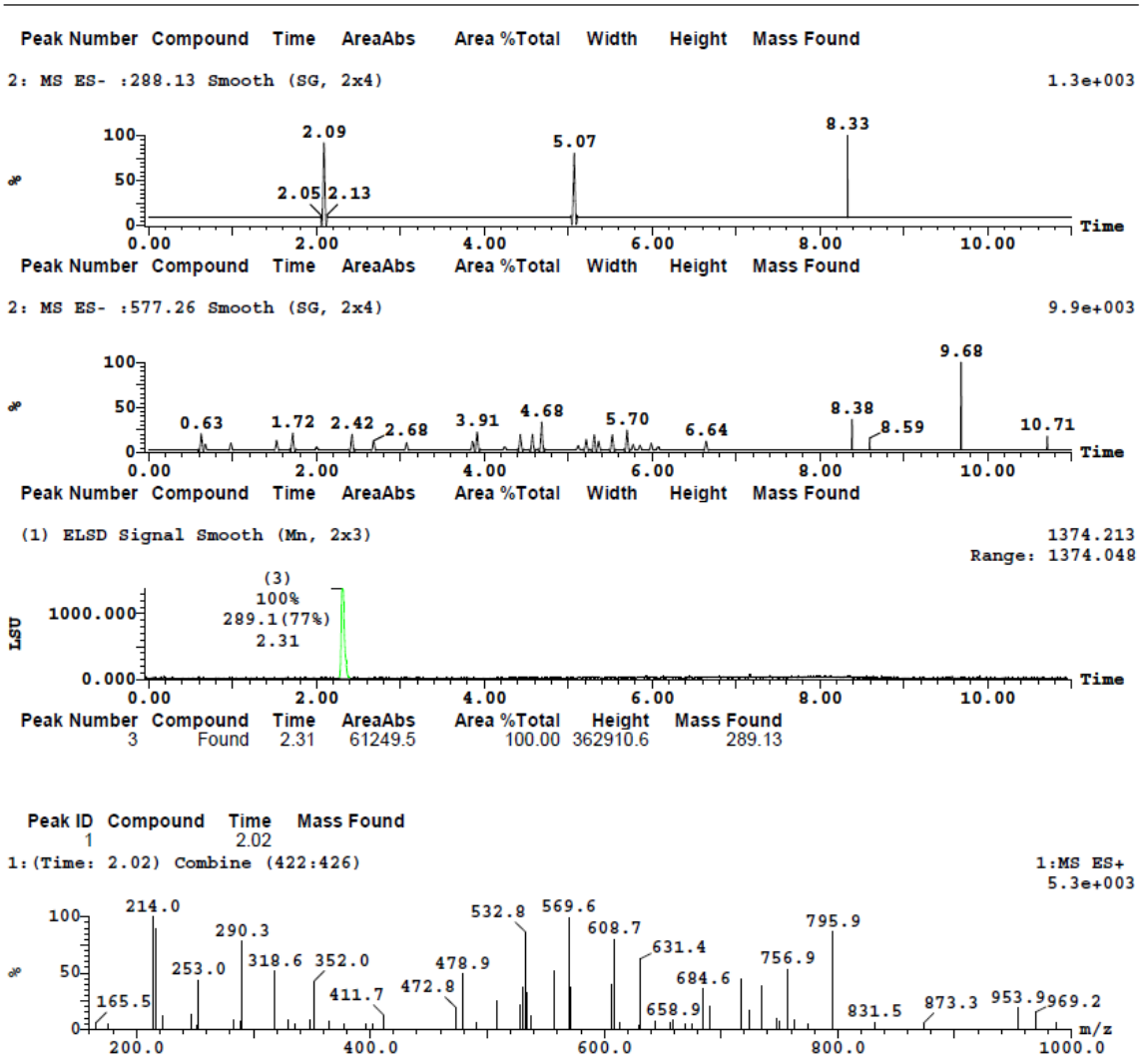


Peak ID	Compound	Time	Mass Found
2	Found	2.86	305.13



HT-LC-MS Spectrum (SOP 2200) of **8i**. UV purity: 100 %

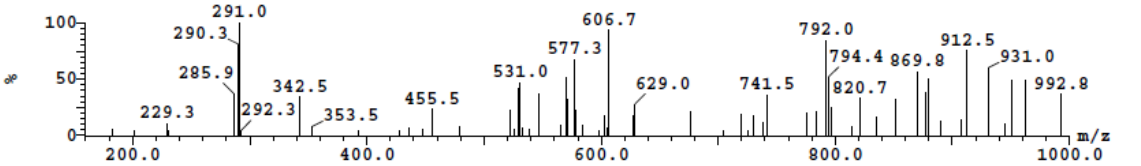




Peak ID	Compound	Time	Mass Found
2		2.26	

2:(Time: 2.26) Combine (472:476)

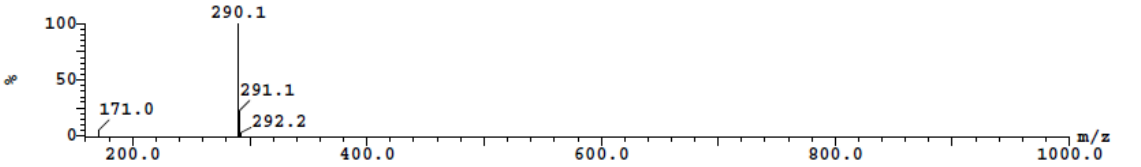
1:MS ES+
5.1e+003



Peak ID	Compound	Time	Mass Found
3	Found	2.31	289.13

3:(Time: 2.31) Combine (481:485)

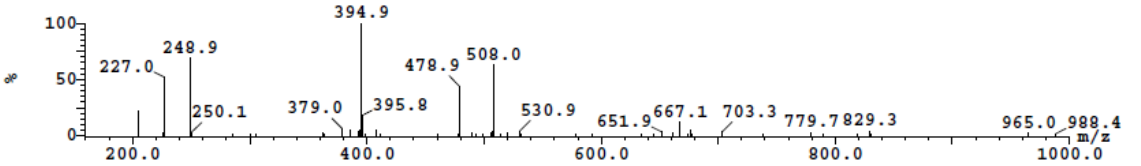
1:MS ES+
8.9e+006



Peak ID	Compound	Time	Mass Found
3		2.31	

3:(Time: 2.31) Combine (481:485)

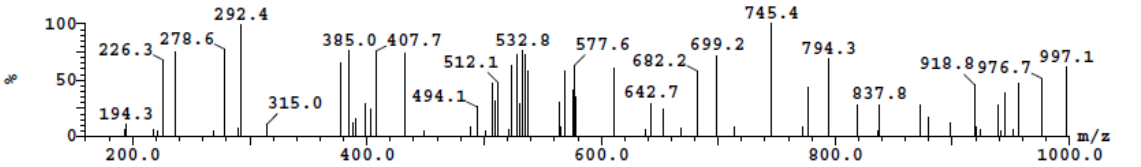
2:MS ES-
7.9e+004



Peak ID	Compound	Time	Mass Found
4		2.88	

4:(Time: 2.88) Combine (602:606)

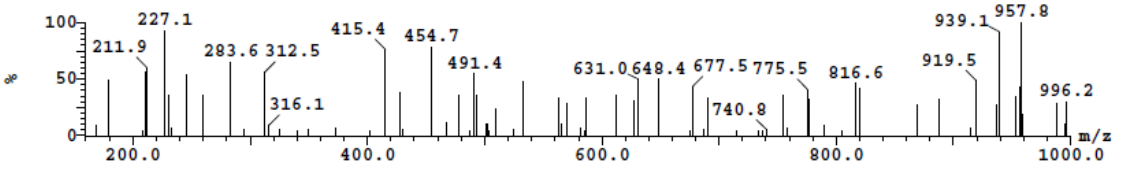
1:MS ES+
4.4e+003



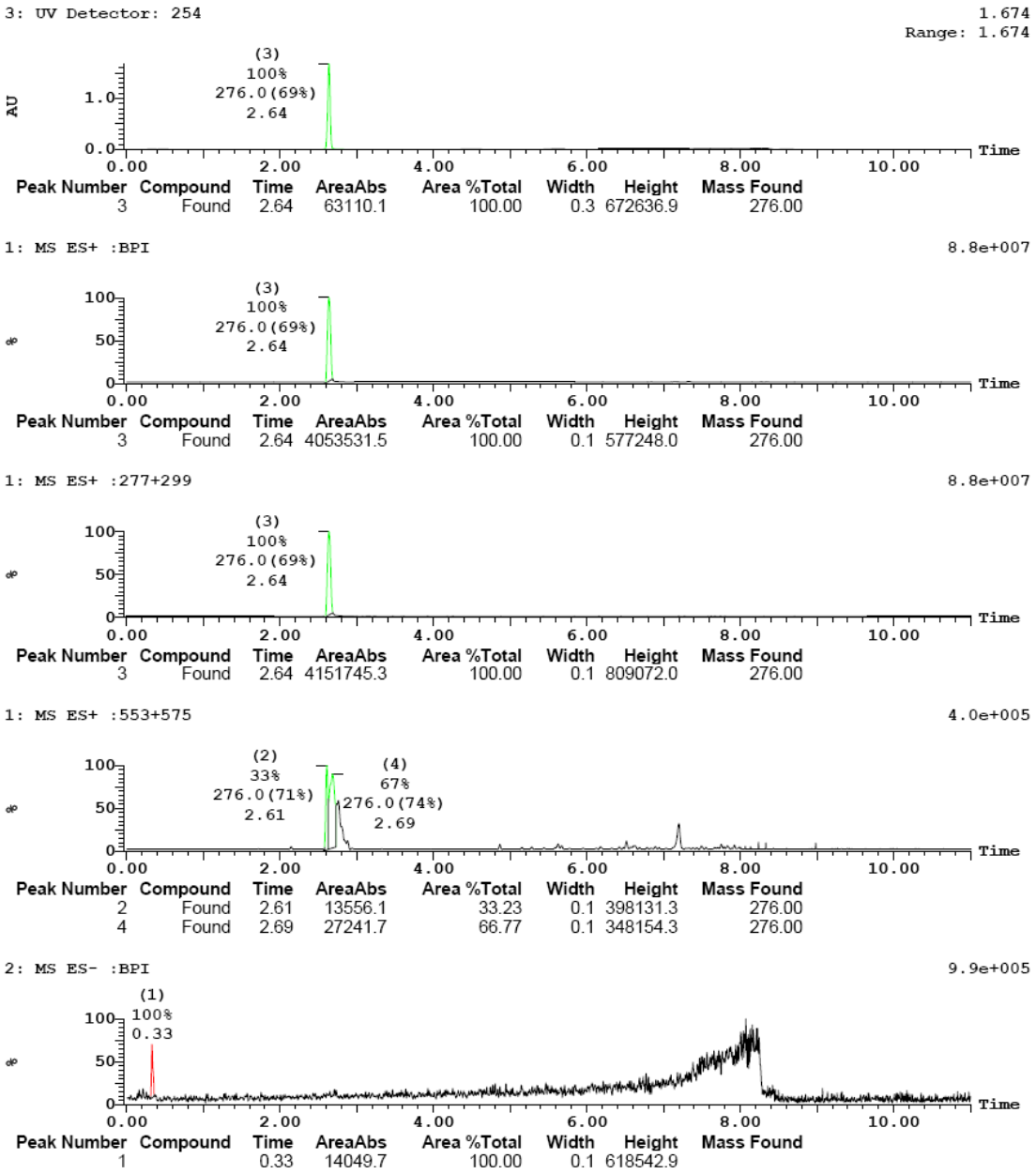
Peak ID	Compound	Time	Mass Found
5		3.02	

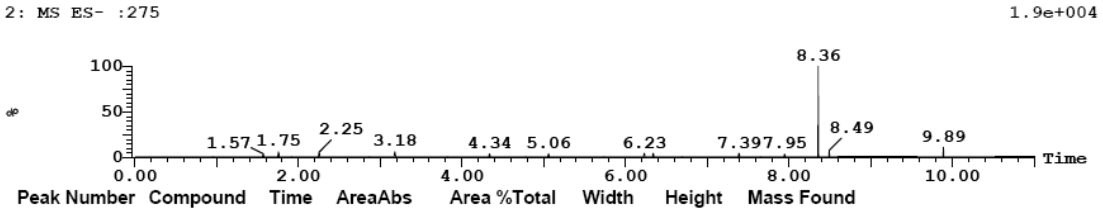
5:(Time: 3.02) Combine (631:635)

1:MS ES+
5.7e+003

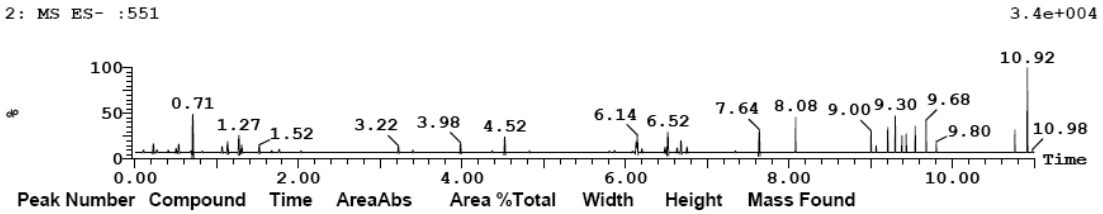


HT-LC-MS Spectrum (SOP 2200) of **8j**. UV purity: 100 %

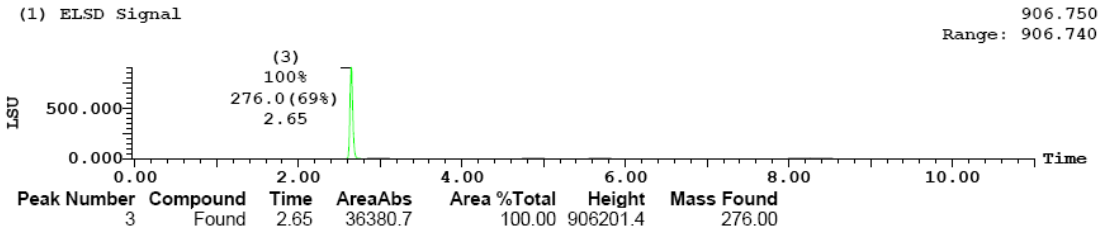




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

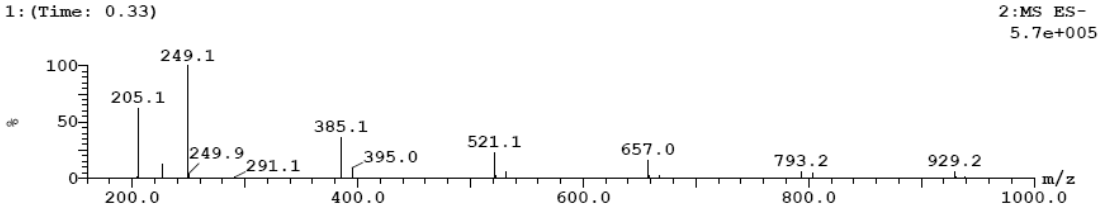


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

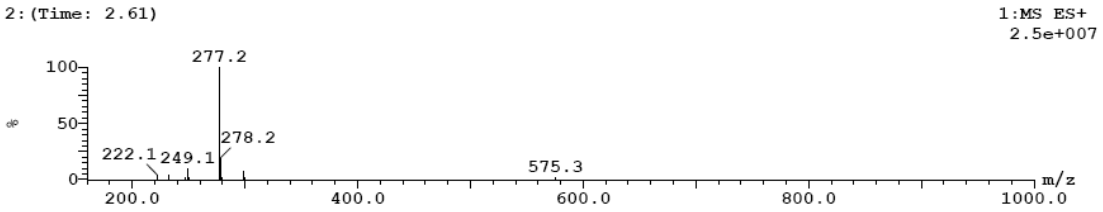


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
3	Found	2.65	36380.7	100.00	906201.4	276.00

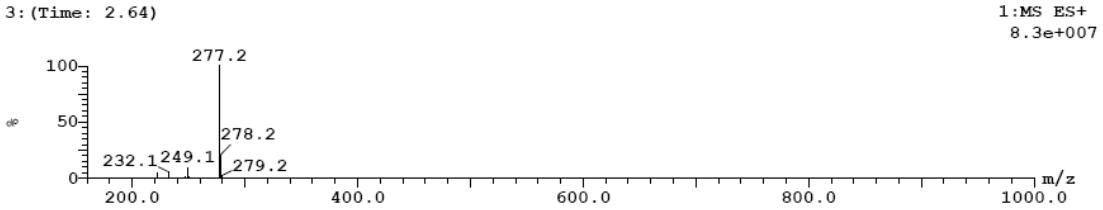
Peak ID	Compound	Time	Mass Found
1		0.33	



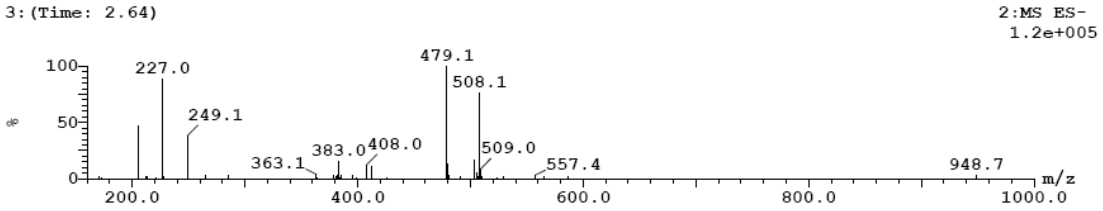
Peak ID	Compound	Time	Mass Found
2	Found	2.61	276.00



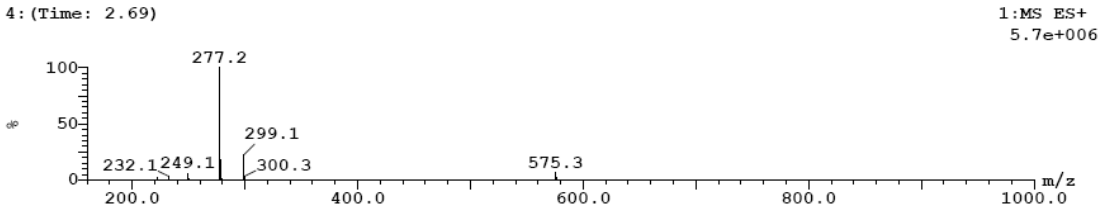
Peak ID	Compound	Time	Mass Found
3	Found	2.64	276.00



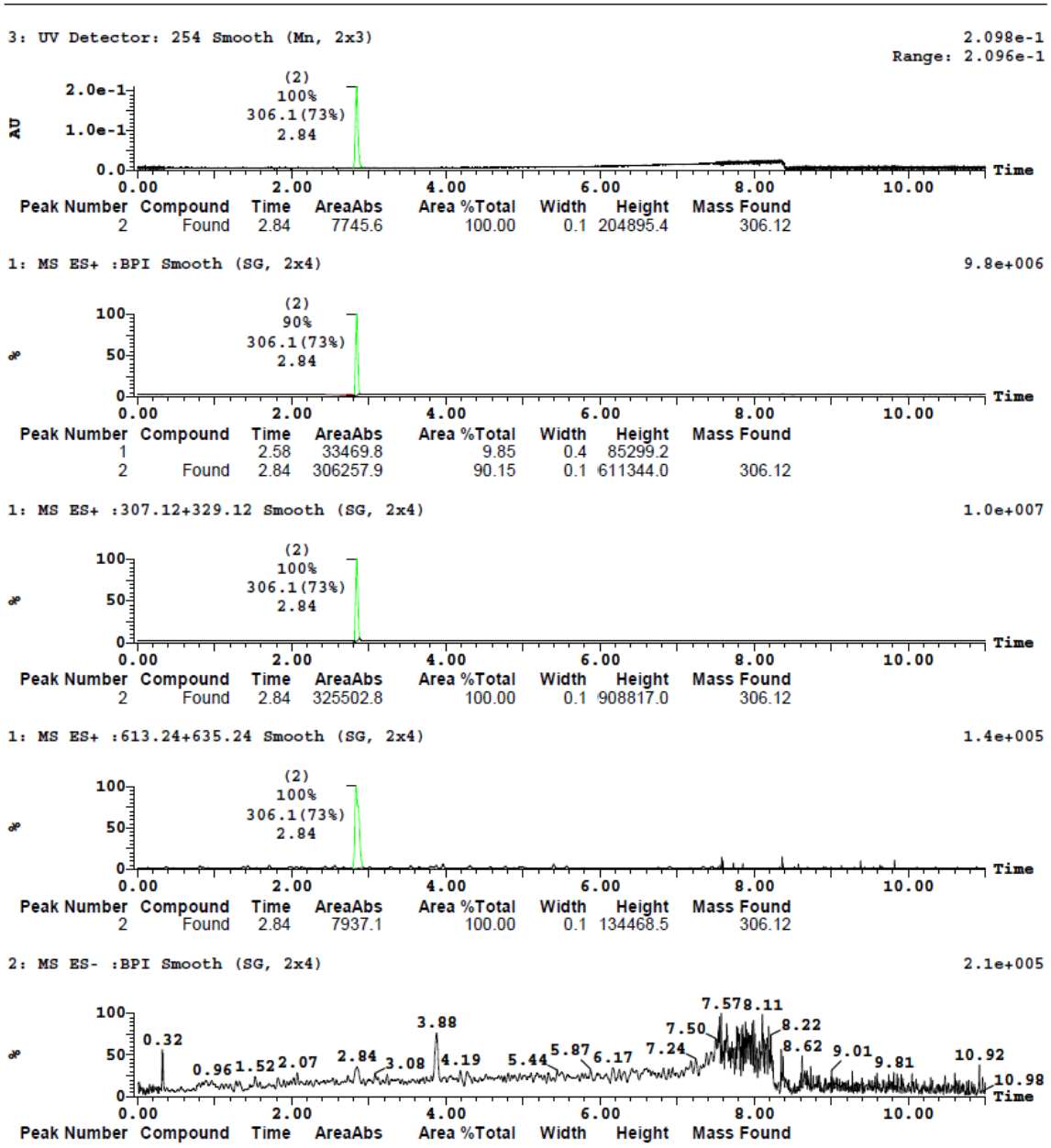
Peak ID	Compound	Time	Mass Found
3		2.64	

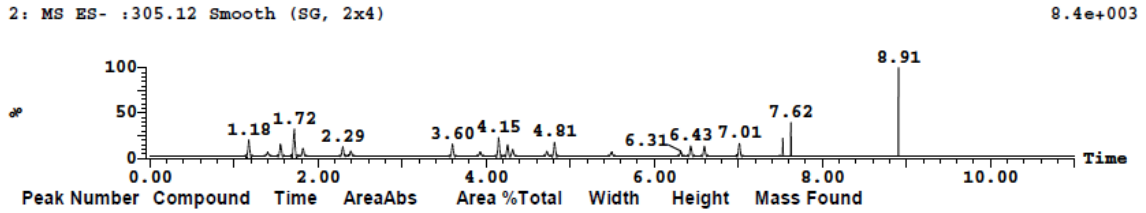


Peak ID	Compound	Time	Mass Found
4	Found	2.69	276.00

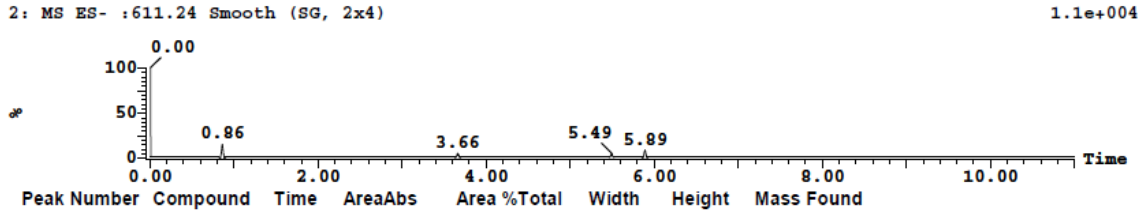


HT-LC-MS Spectrum (SOP 2200) of **8k**. UV purity: 100 %

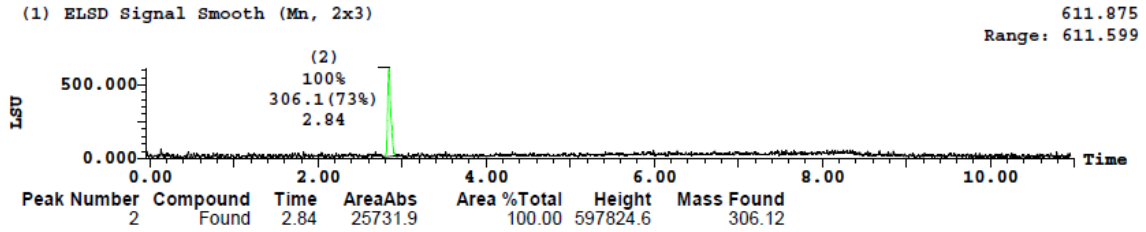




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

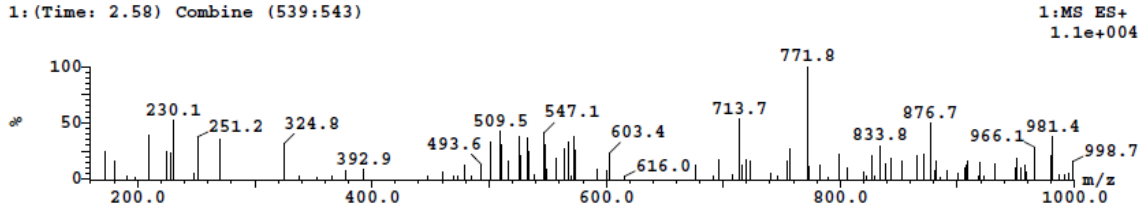


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

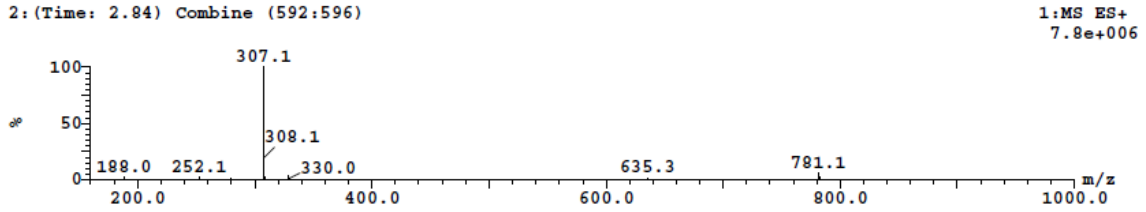


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
2	Found	2.84	25731.9	100.00	597824.6	306.12

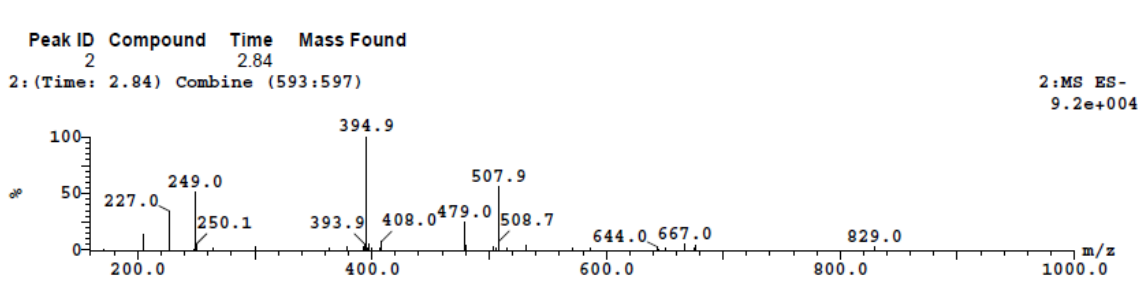
Peak ID	Compound	Time	Mass Found
1		2.58	



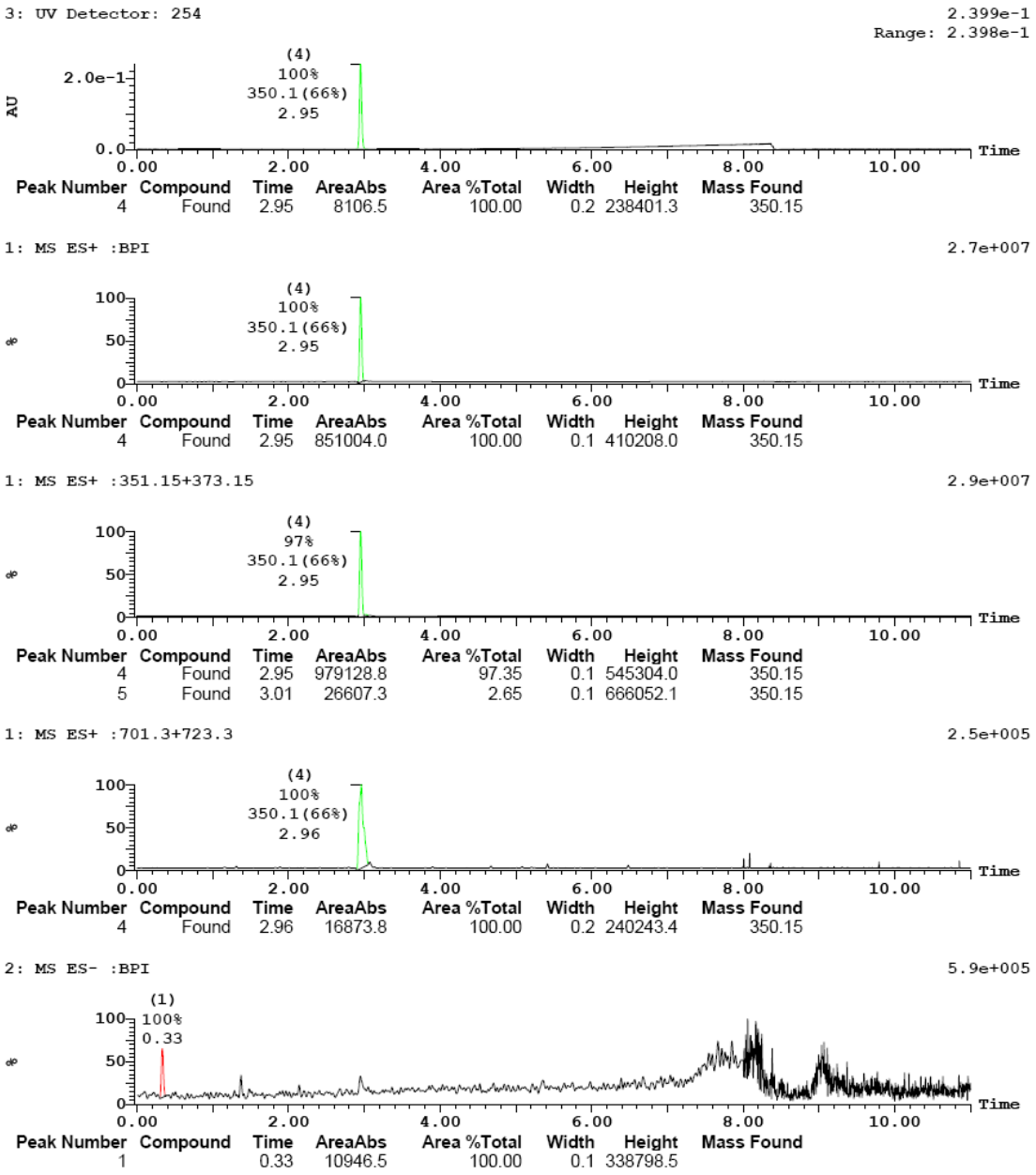
Peak ID	Compound	Time	Mass Found
2	Found	2.84	306.12

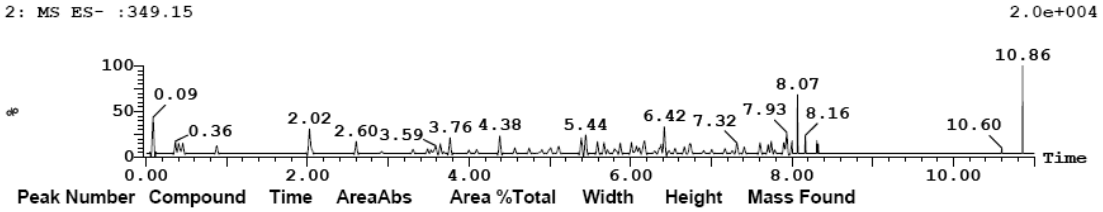


Peak ID	Compound	Time	Mass Found
2		2.84	

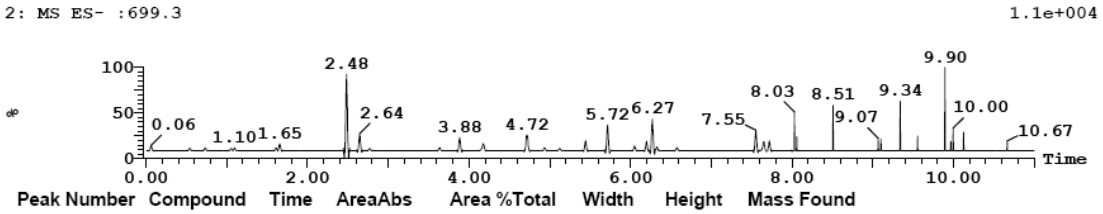


HT-LC-MS Spectrum (SOP 2200) of **8l**. UV purity: 100 %

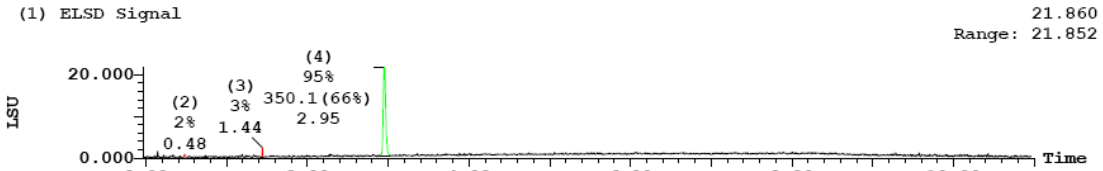




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

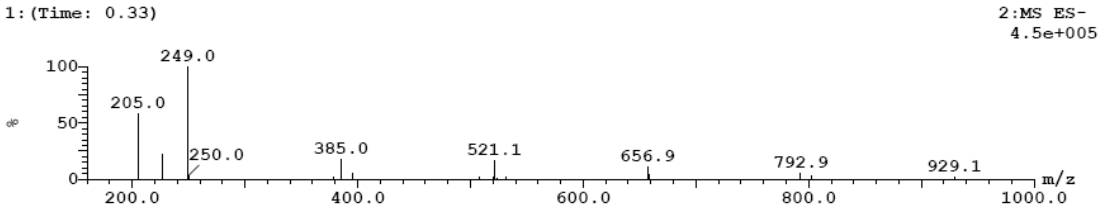


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

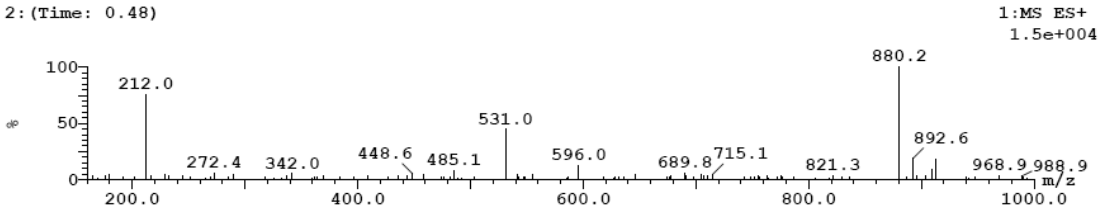


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
2		0.48	18.3	2.24	862.8	
3		1.44	22.9	2.79	2265.4	
4	Found	2.95	778.2	94.97	21338.2	350.15

Peak ID	Compound	Time	Mass Found
1		0.33	

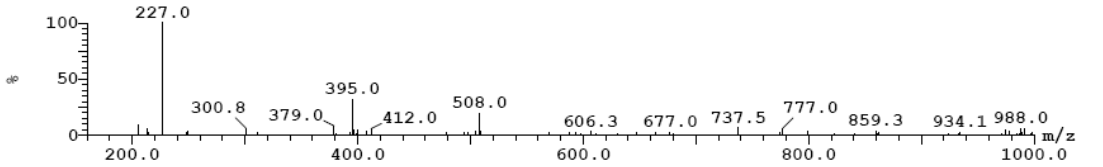


Peak ID	Compound	Time	Mass Found
2		0.48	



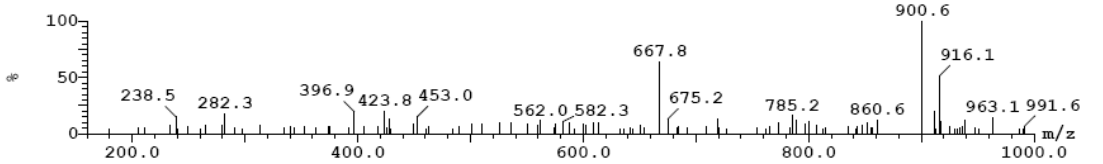
Peak ID	Compound	Time	Mass Found
2		0.48	

2:(Time: 0.48) 2:MS ES- 9.0e+004



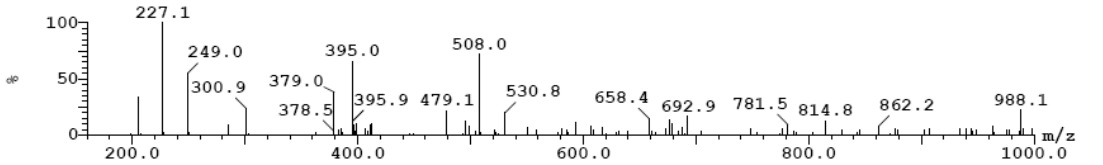
Peak ID	Compound	Time	Mass Found
3		1.44	

3:(Time: 1.44) 1:MS ES+ 5.1e+003



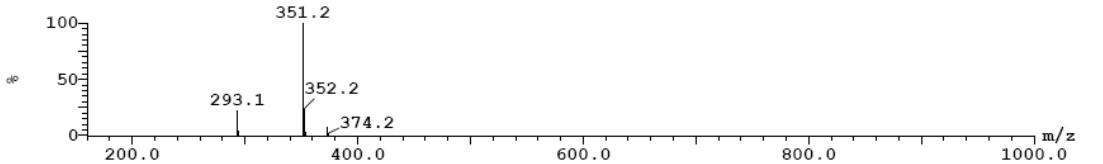
Peak ID	Compound	Time	Mass Found
3		1.44	

3:(Time: 1.44) 2:MS ES- 3.7e+004



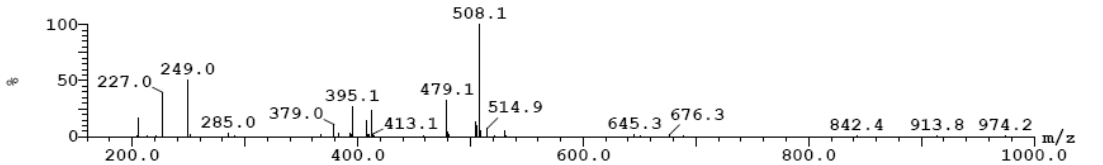
Peak ID	Compound	Time	Mass Found
4	Found	2.95	350.15

4:(Time: 2.95) 1:MS ES+ 2.5e+007



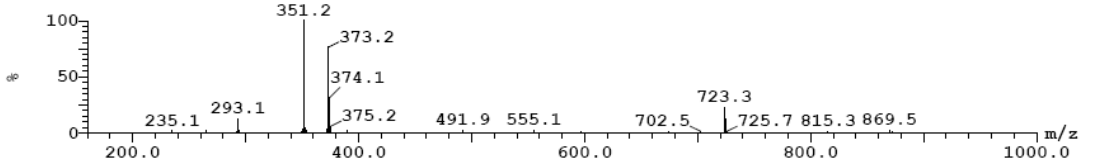
Peak ID	Compound	Time	Mass Found
4		2.95	

4:(Time: 2.95) 2:MS ES- 1.9e+005

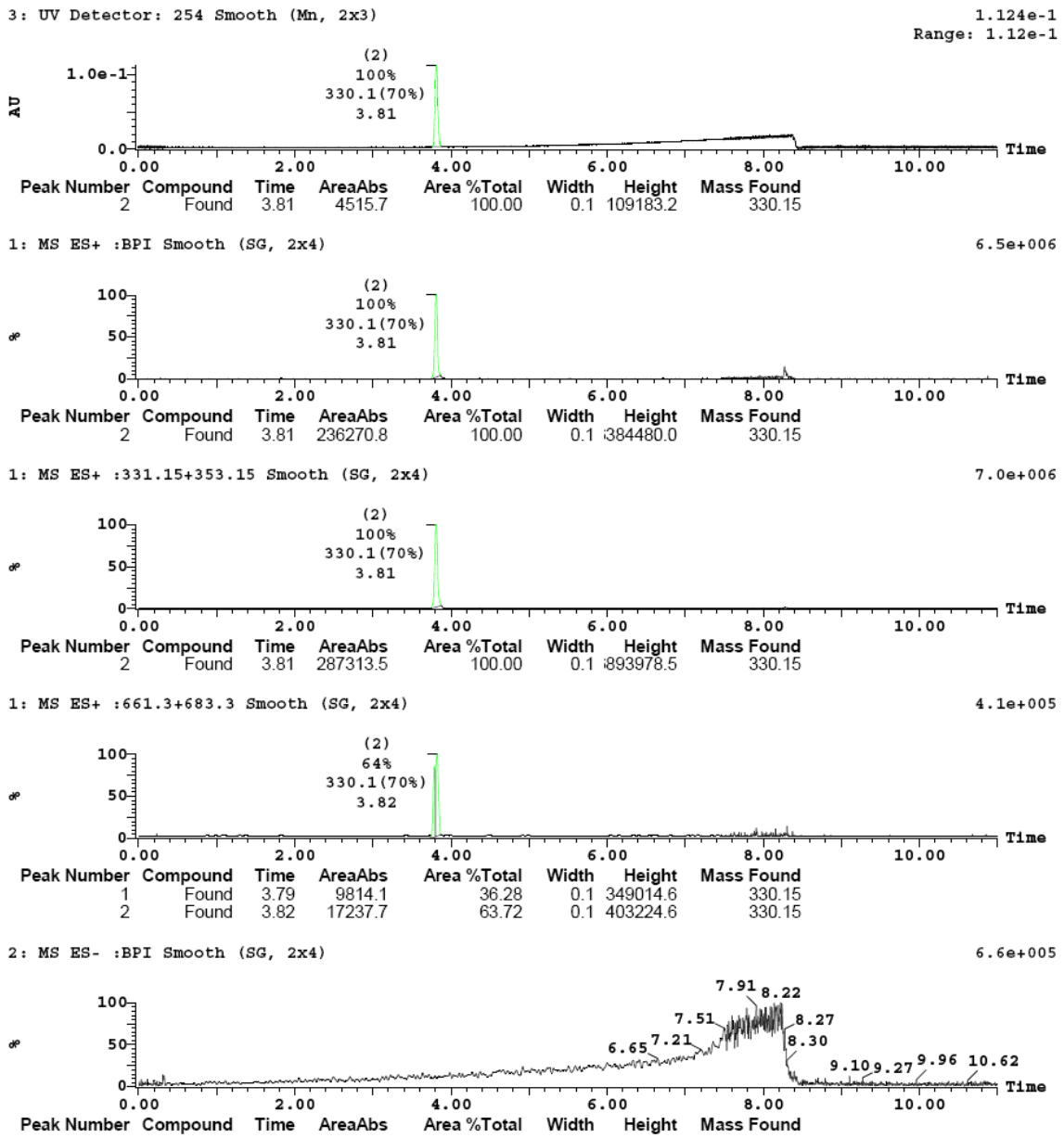


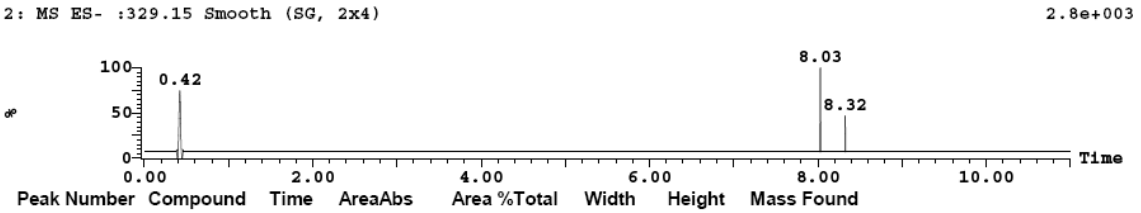
Peak ID	Compound	Time	Mass Found
5	Found	3.01	350.15

5:(Time: 3.01) 1:MS ES+ 3.9e+005

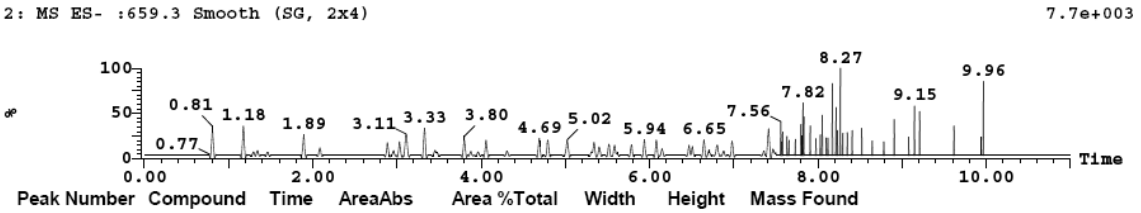


HT-LC-MS Spectrum (SOP 2200) of **8m**. UV purity: 100 %

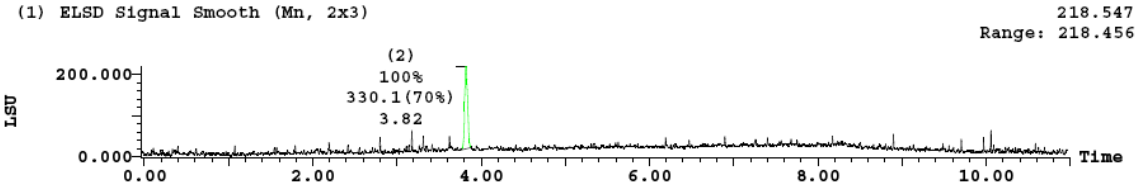




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

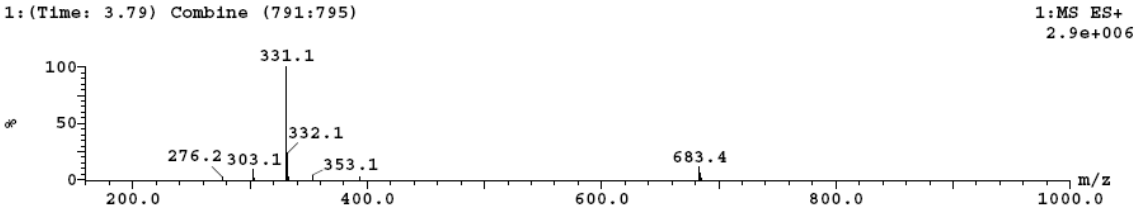


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

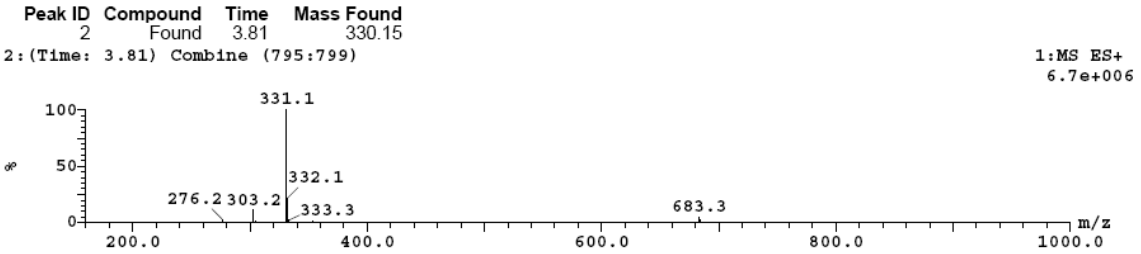


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
2	Found	3.82	8181.3	100.00	198104.1	330.15

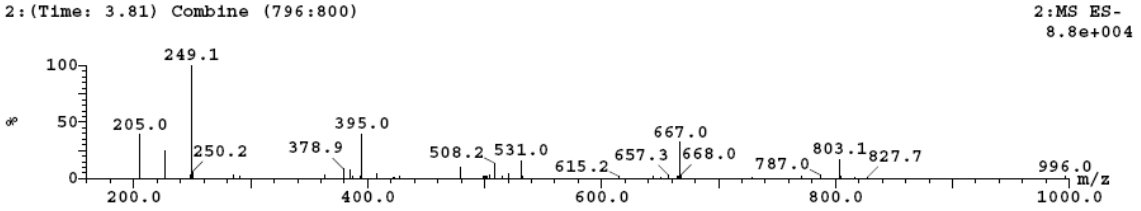
Peak ID	Compound	Time	Mass Found
1	Found	3.79	330.15



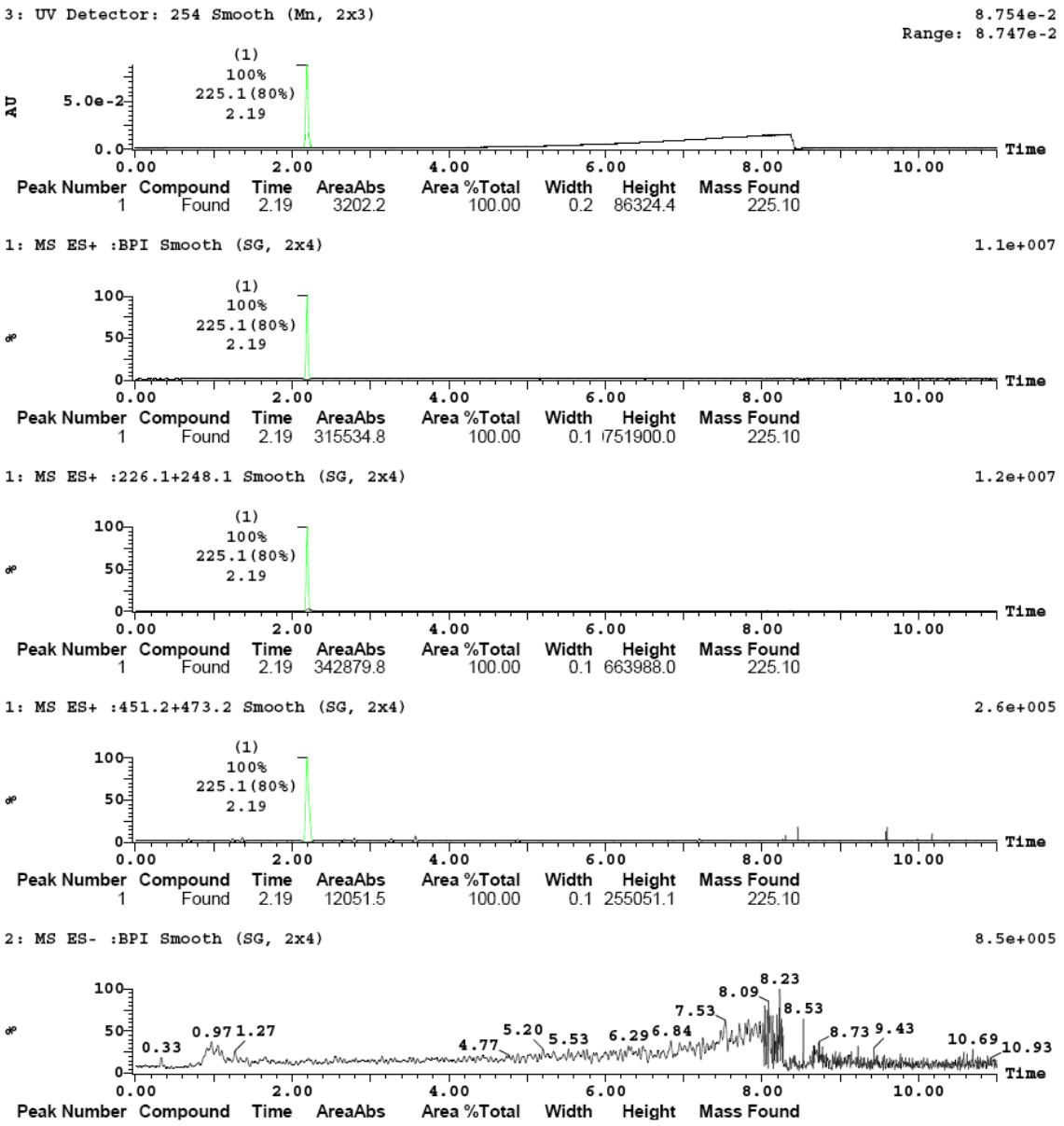
Peak ID	Compound	Time	Mass Found
2	Found	3.81	330.15

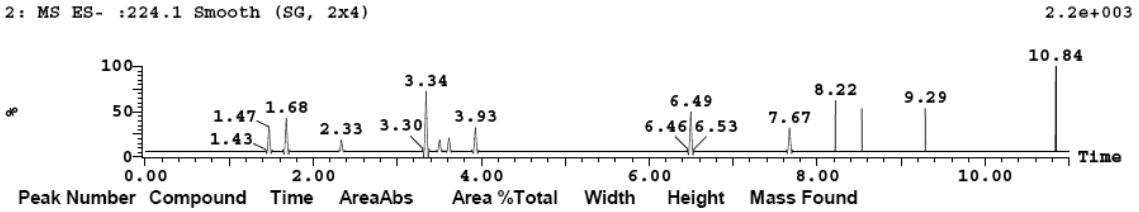


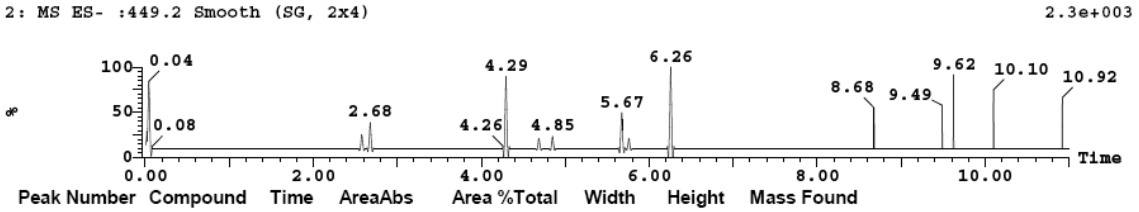
Peak ID	Compound	Time	Mass Found
2		3.81	

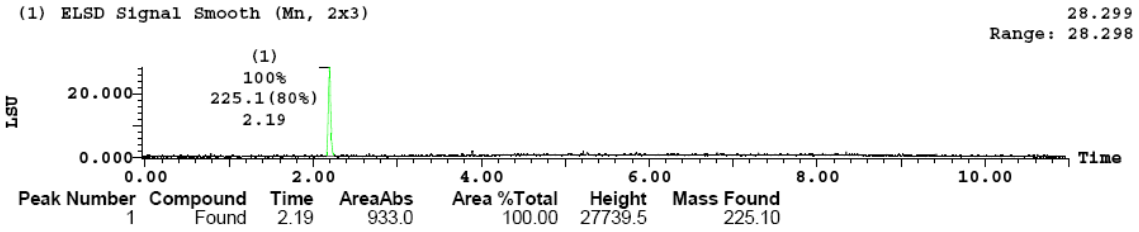


HT-LC-MS Spectrum (SOP 2200) of **8n**. UV purity: 100 %

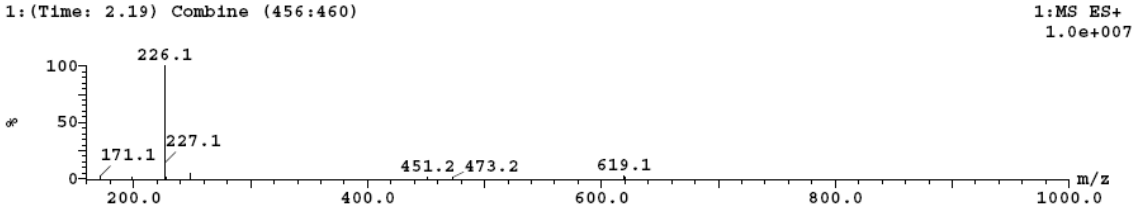




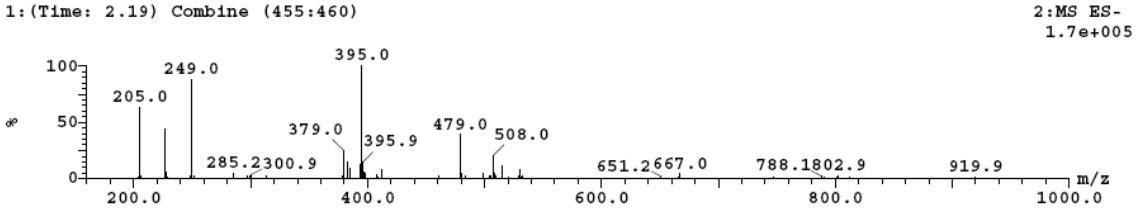




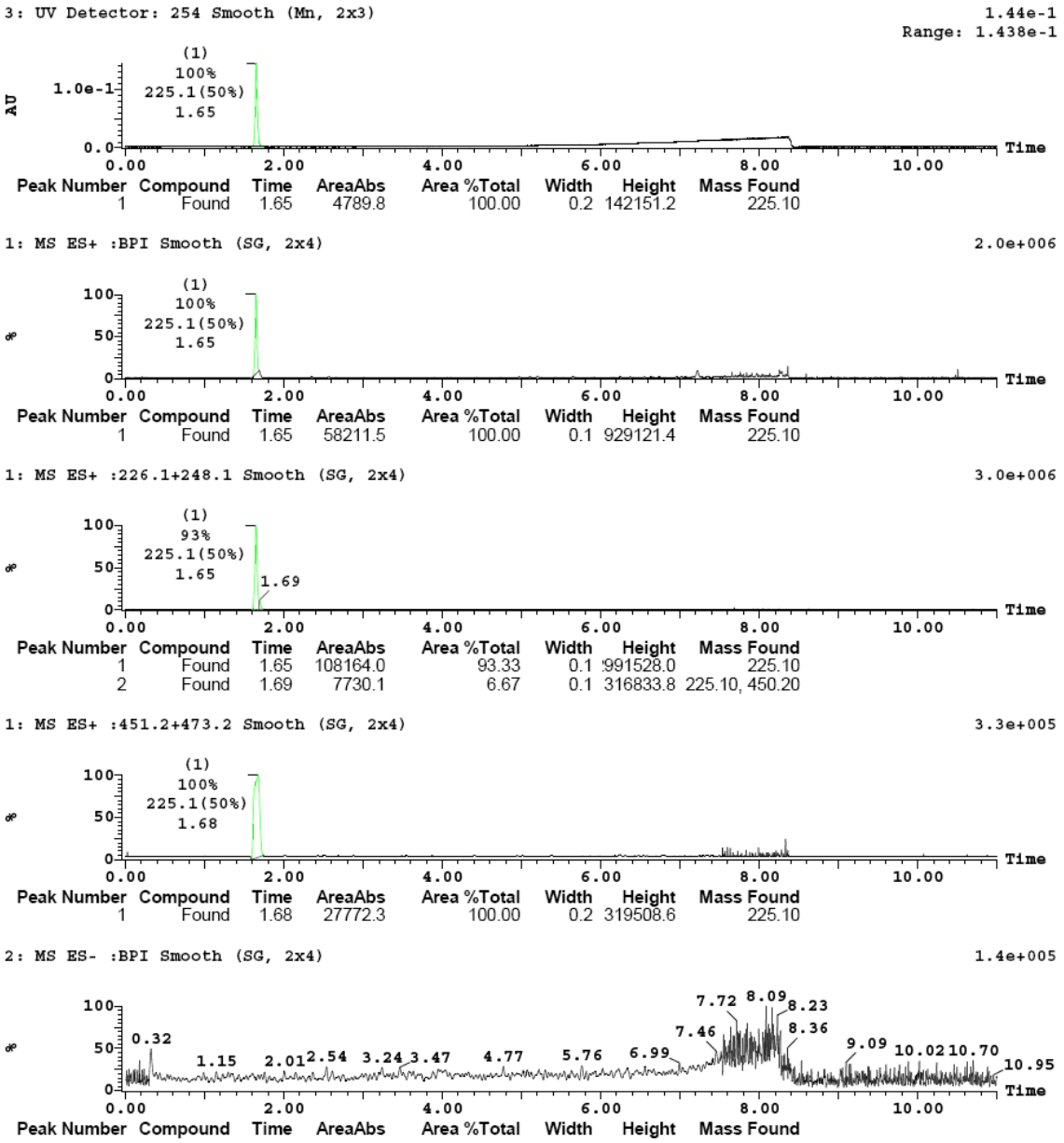
Peak ID Compound Time Mass Found
1 Found 2.19 225.10

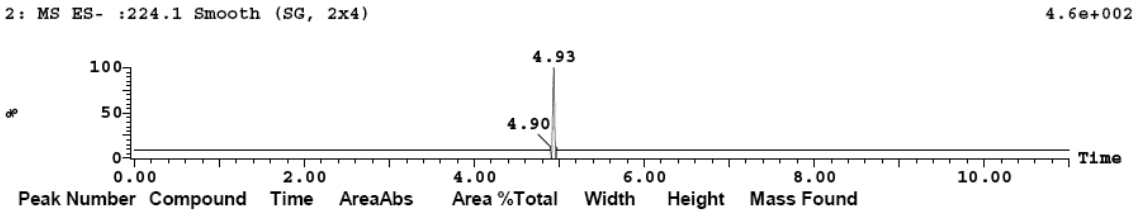


Peak ID Compound Time Mass Found
1 2.19

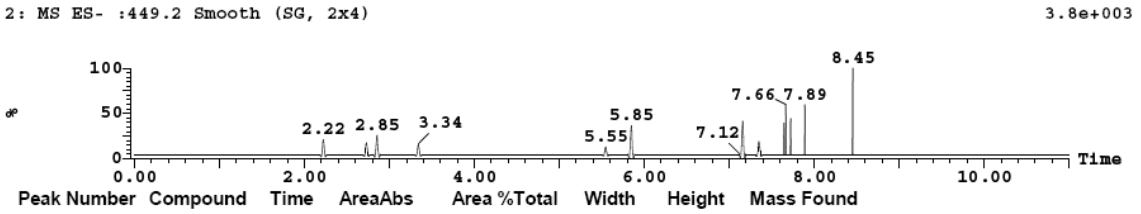


HT-LC-MS Spectrum (SOP 2200) of **8o**. UV purity: 100 %

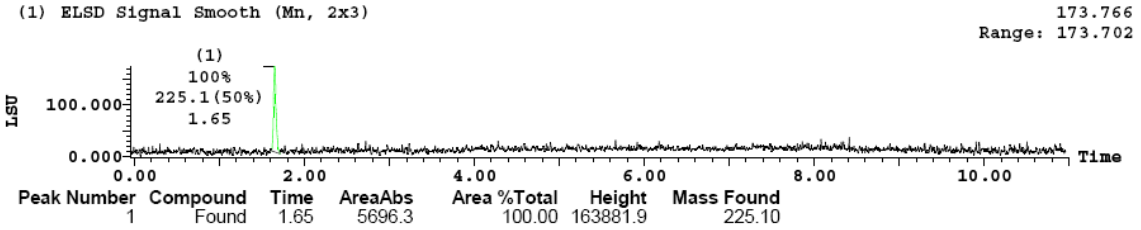




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

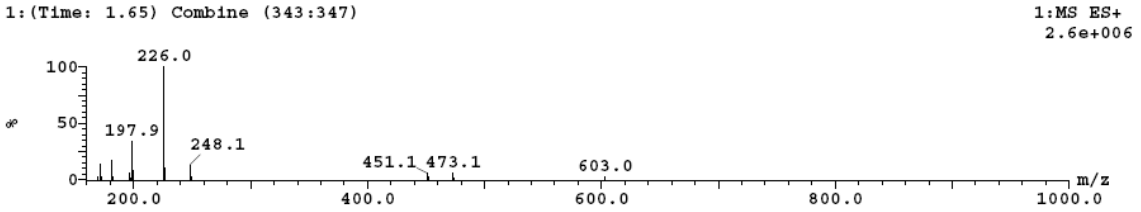


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

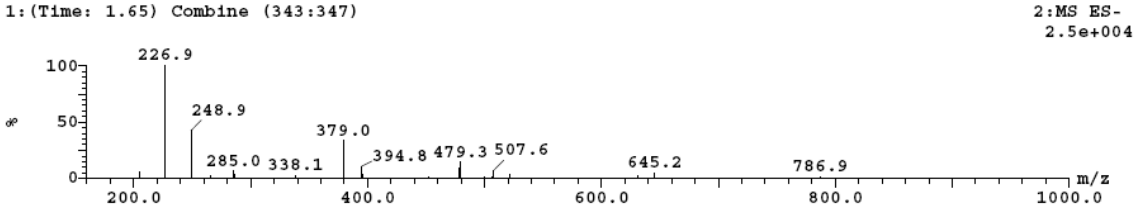


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
1	Found	1.65	5696.3	100.00	163881.9	225.10

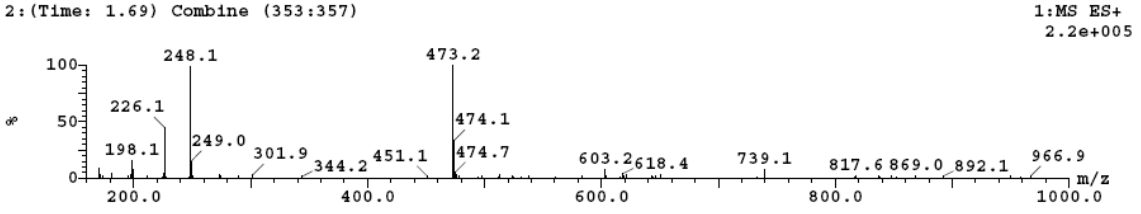
Peak ID	Compound	Time	Mass Found
1	Found	1.65	225.10



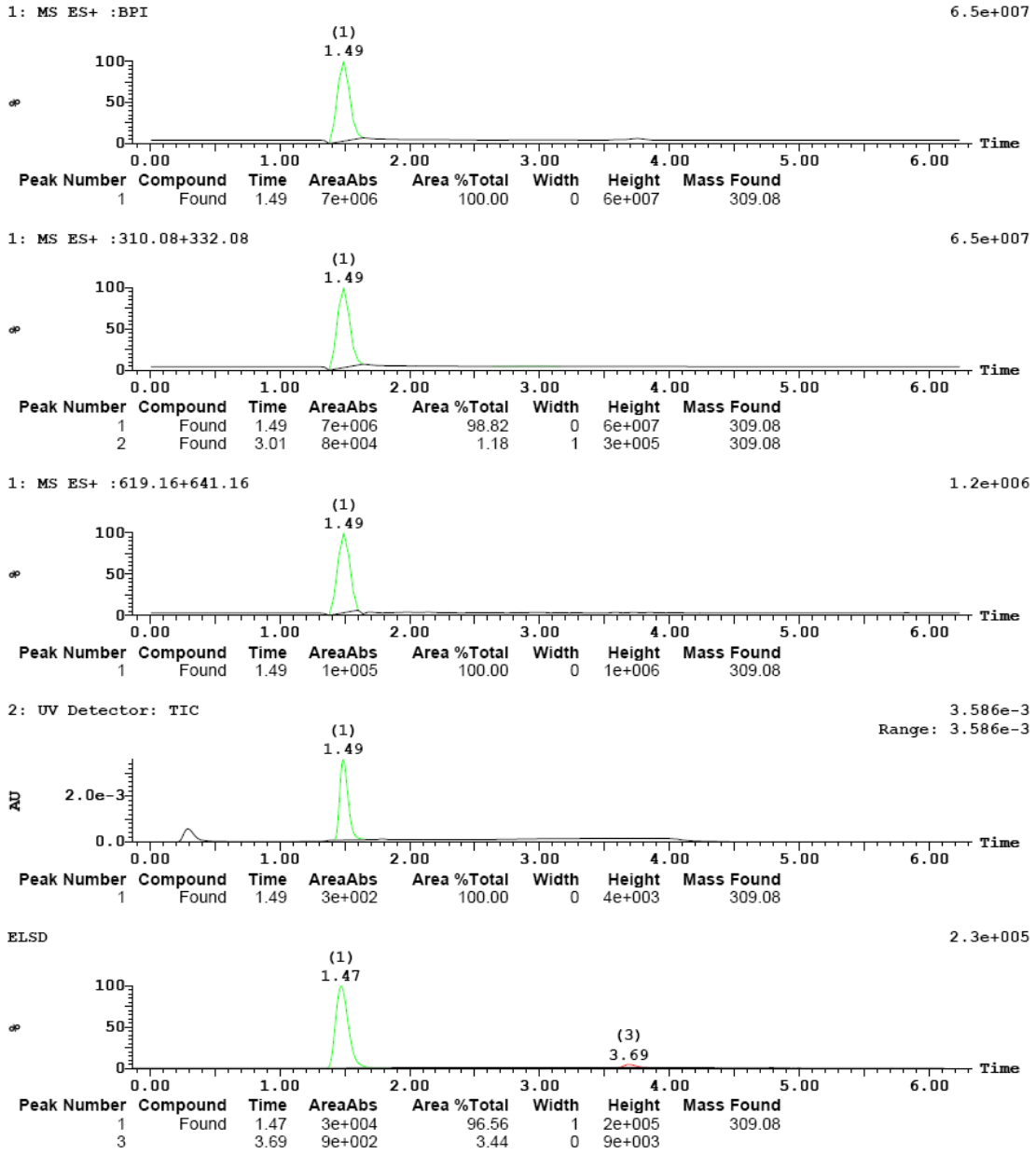
Peak ID	Compound	Time	Mass Found
1		1.65	



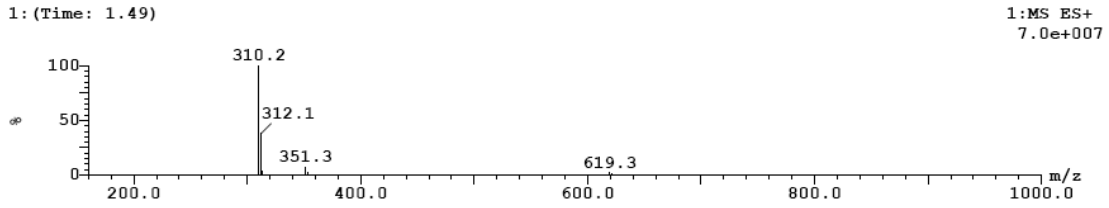
Peak ID	Compound	Time	Mass Found
2	Found	1.69	225.10, 450.20



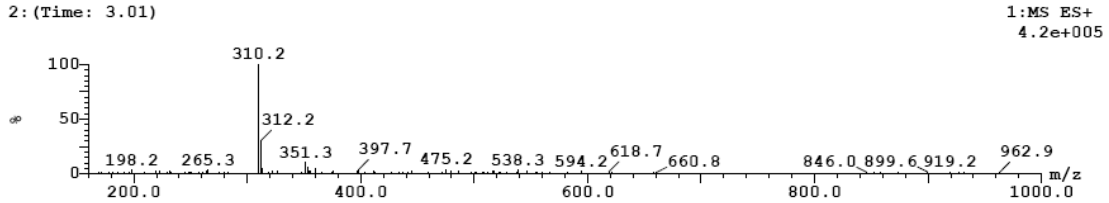
HT-LC-MS Spectrum (SOP 2222) of **8p**. UV purity: 100 %



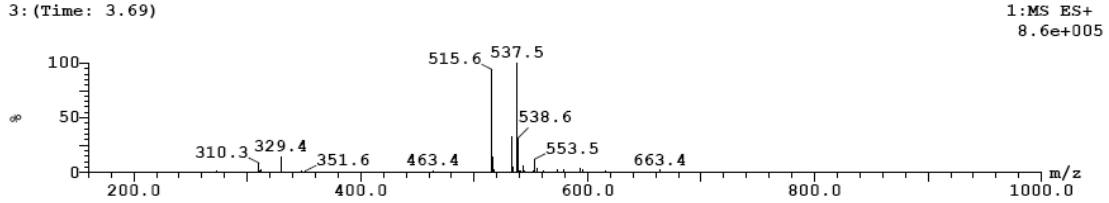
Peak ID	Compound	Time	Mass Found
1	Found	1.49	309.08



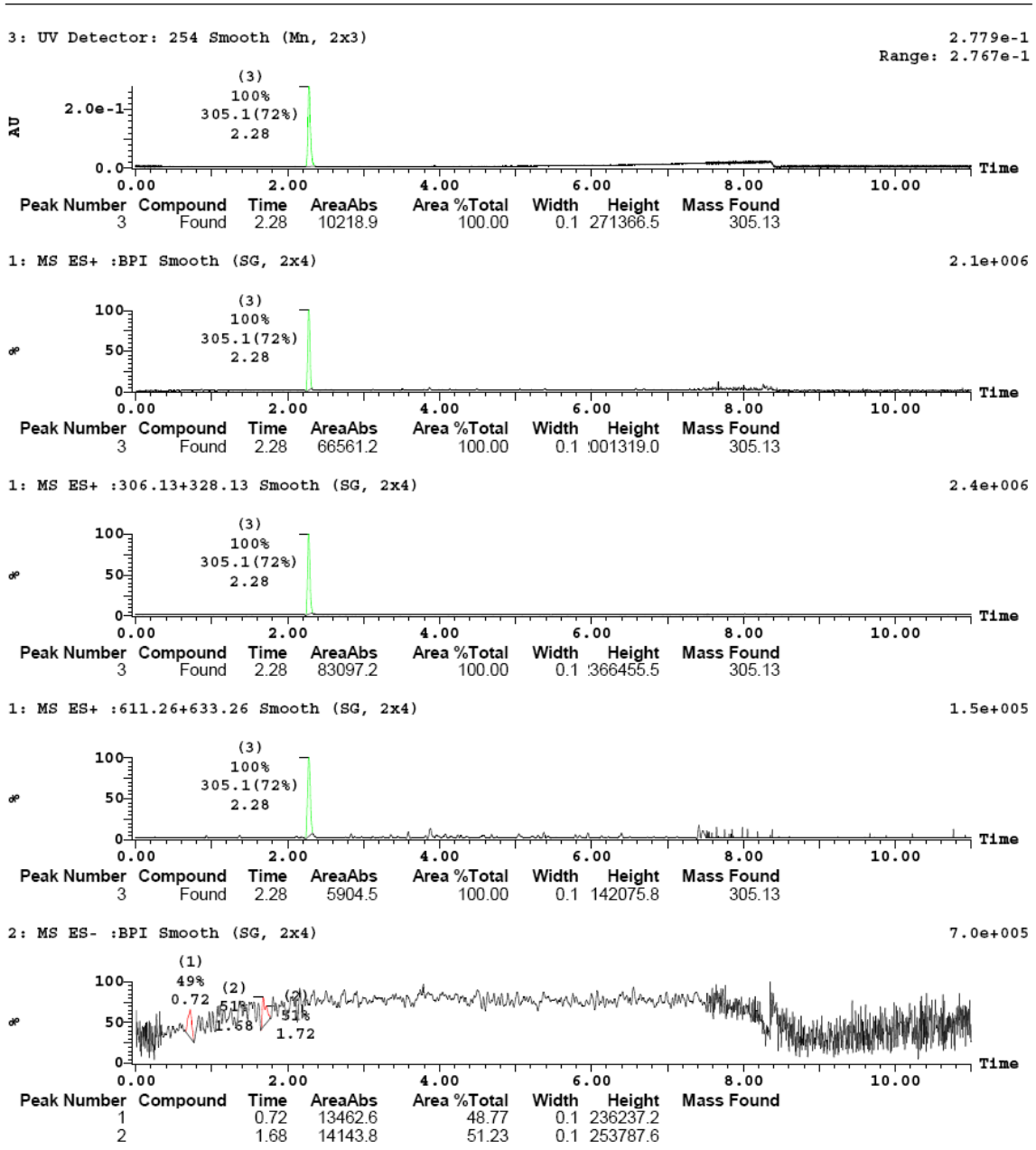
Peak ID	Compound	Time	Mass Found
2	Found	3.01	309.08

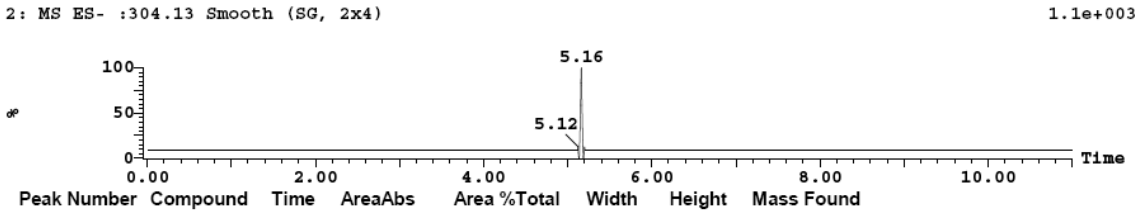


Peak ID	Compound	Time	Mass Found
3		3.69	

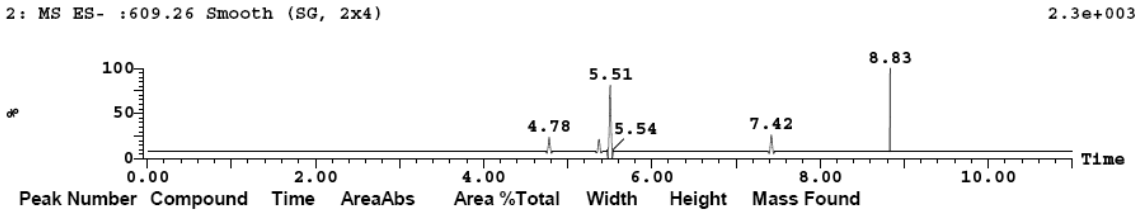


HT-LC-MS Spectrum (SOP 2200) of **8q**. UV purity: 100 %

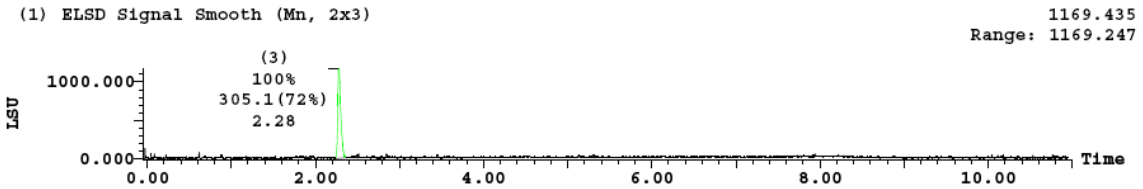




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

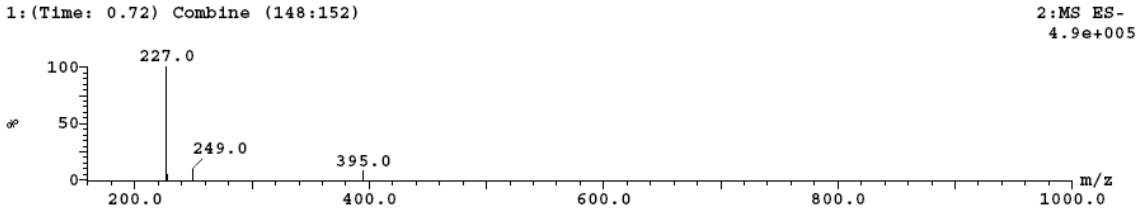


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

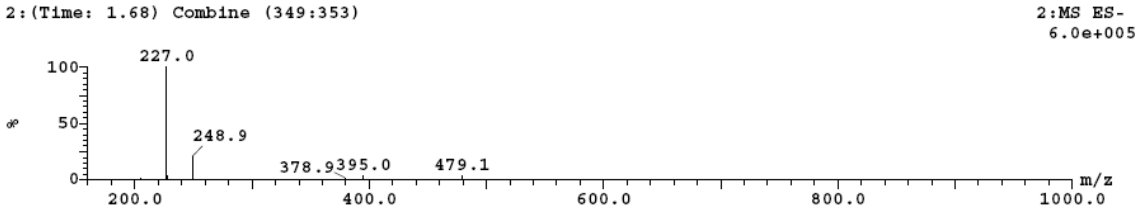


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
3	Found	2.28	48547.3	100.00	156564.0	305.13

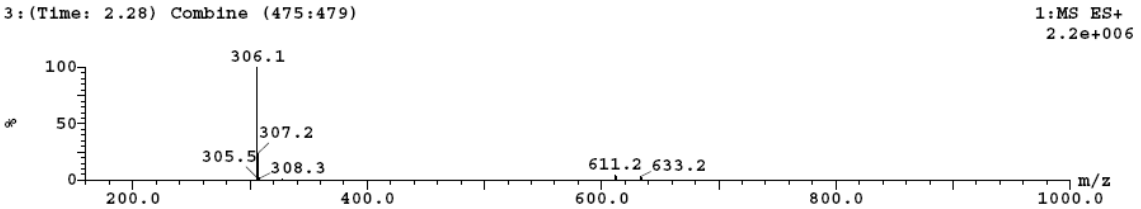
Peak ID	Compound	Time	Mass Found
1		0.72	



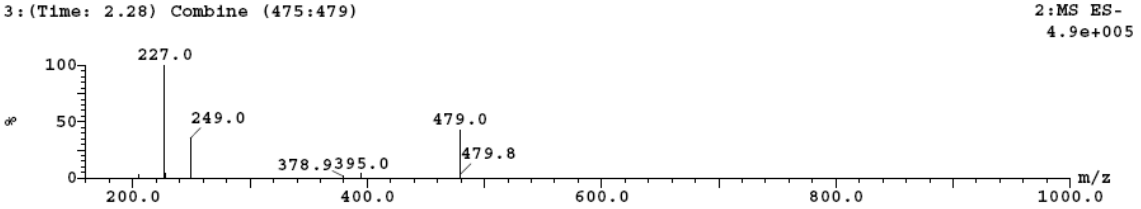
Peak ID	Compound	Time	Mass Found
2		1.68	



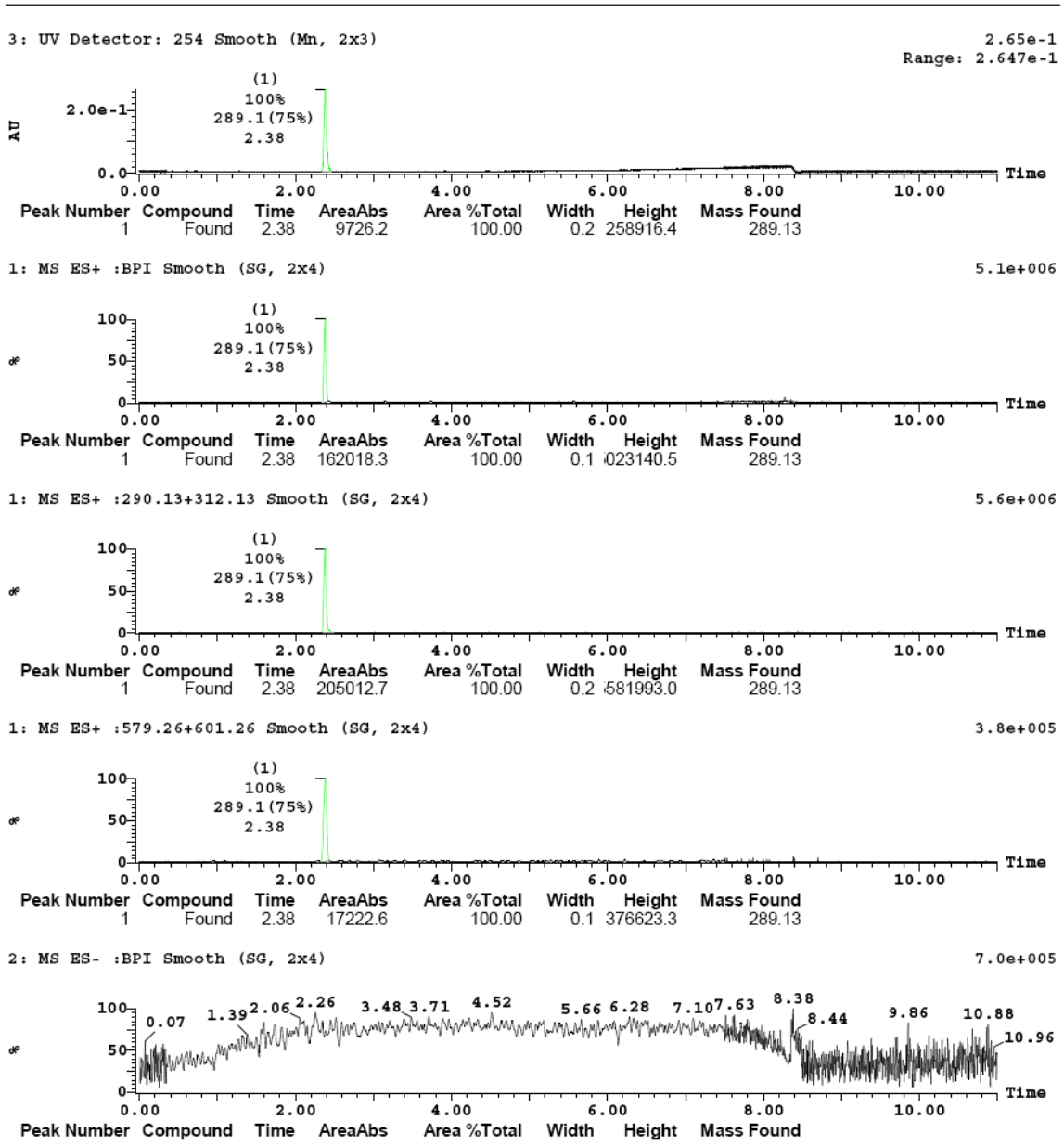
Peak ID	Compound	Time	Mass Found
3	Found	2.28	305.13

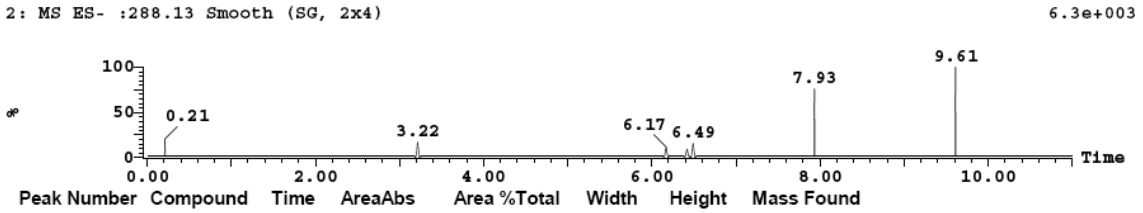


Peak ID	Compound	Time	Mass Found
3		2.28	

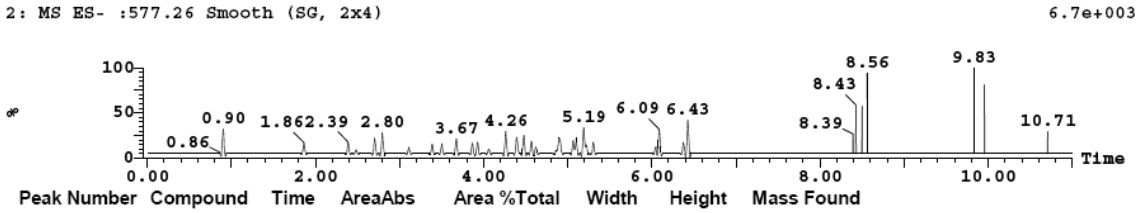


HT-LC-MS Spectrum (SOP 2200) of **8r**. UV purity: 100 %

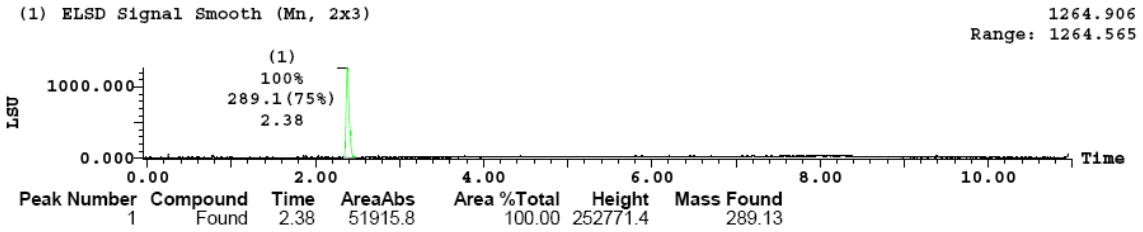




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

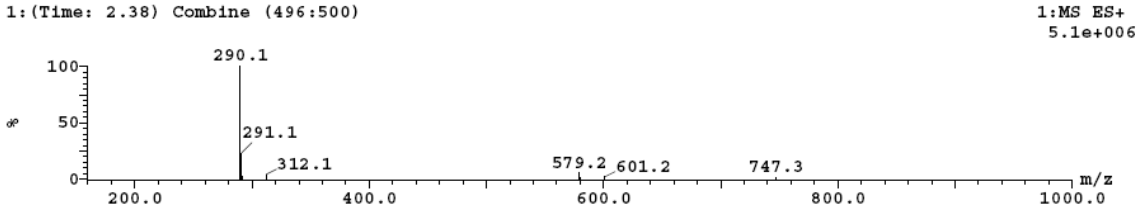


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

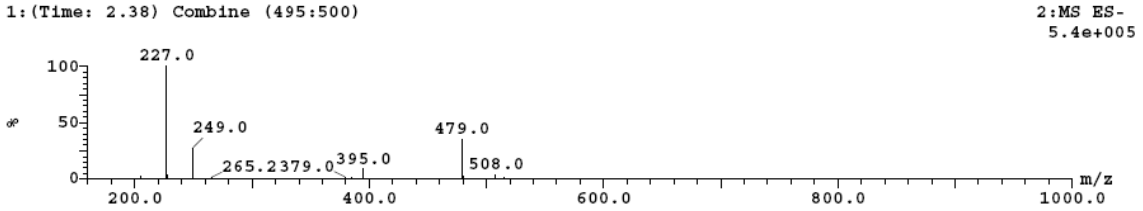


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
1	Found	2.38	51915.8	100.00	252771.4	289.13

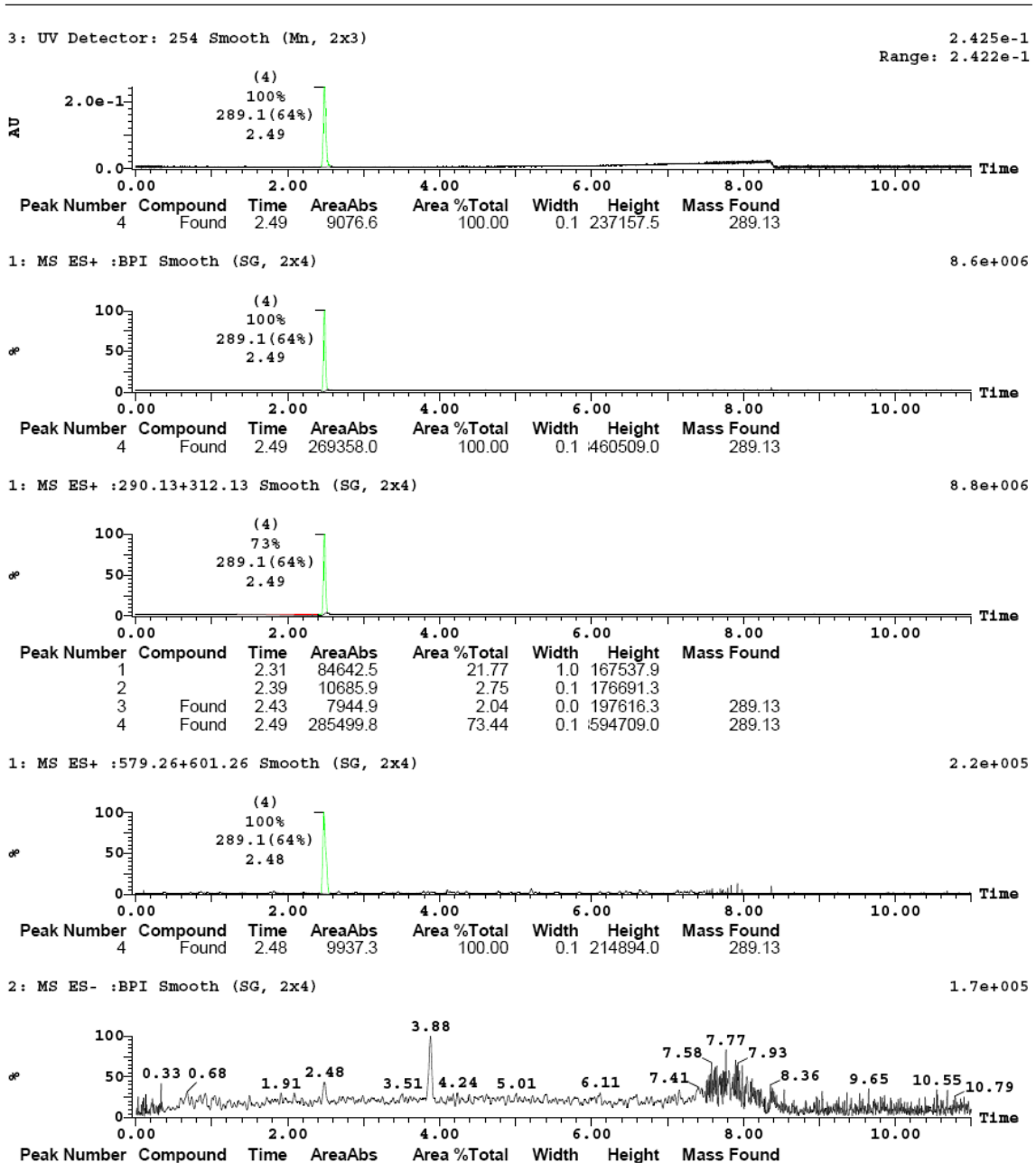
Peak ID	Compound	Time	Mass Found
1	Found	2.38	289.13

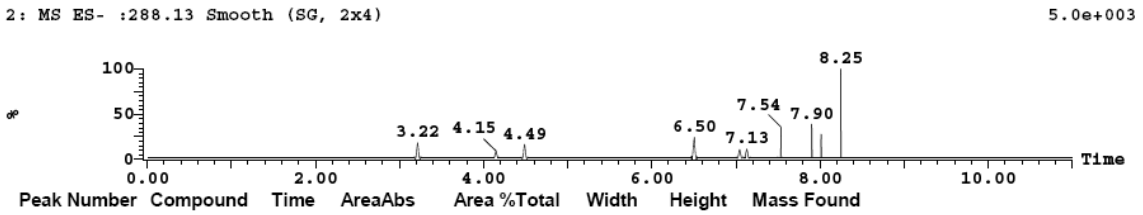


Peak ID	Compound	Time	Mass Found
1		2.38	

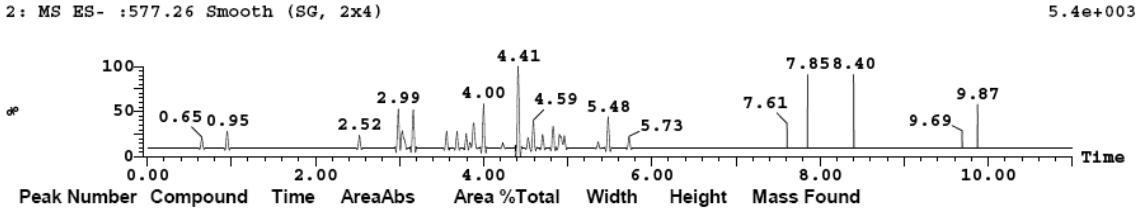


HT-LC-MS Spectrum (SOP 2200) of **8s**. UV purity: 100 %

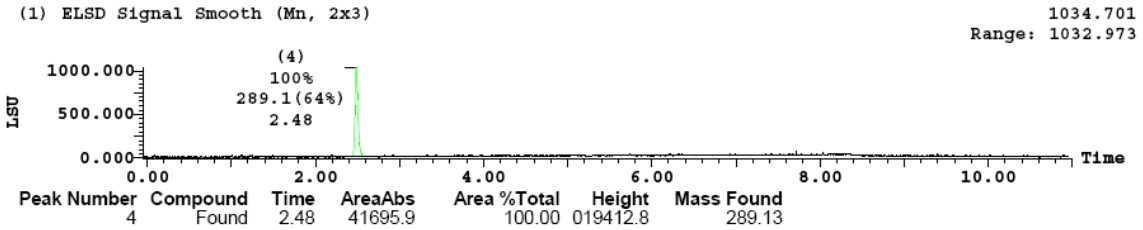




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

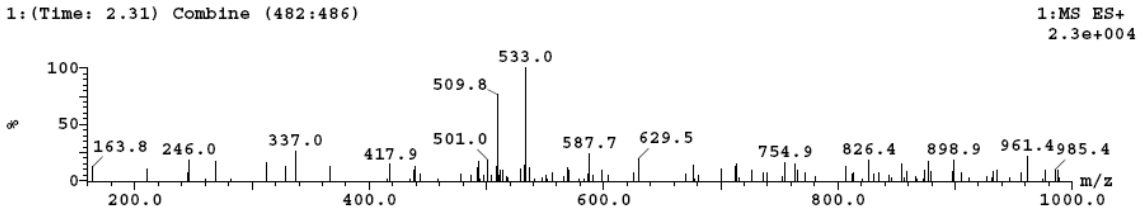


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

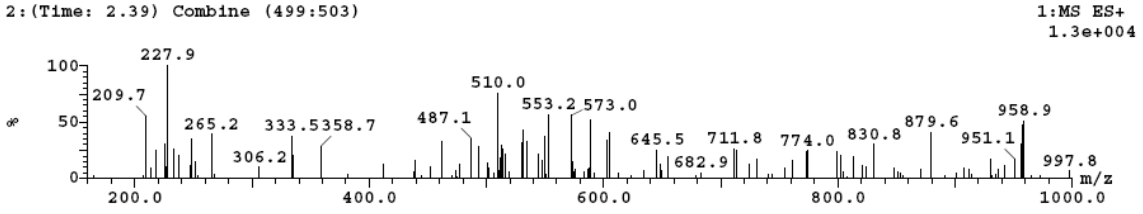


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
4	Found	2.48	41695.9	100.00	019412.8	289.13

Peak ID	Compound	Time	Mass Found
1		2.31	



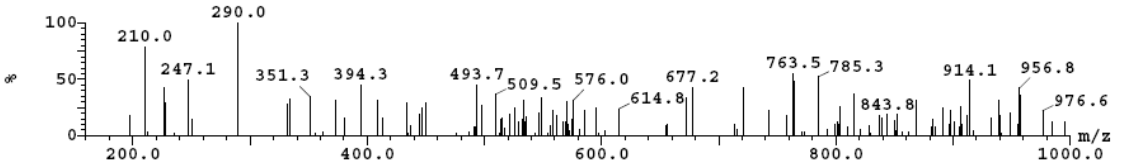
Peak ID	Compound	Time	Mass Found
2		2.39	



Peak ID	Compound	Time	Mass Found
3	Found	2.43	289.13

3:(Time: 2.43) Combine (507:511)

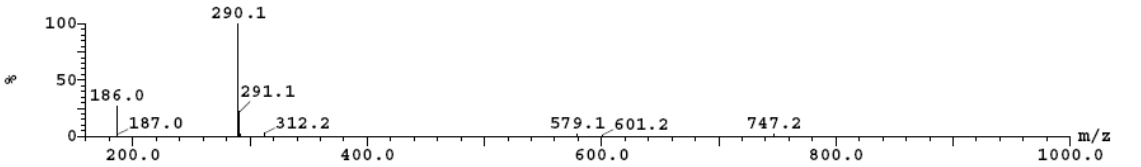
1:MS ES+
1.0e+004



Peak ID	Compound	Time	Mass Found
4	Found	2.49	289.13

4:(Time: 2.48) Combine (517:521)

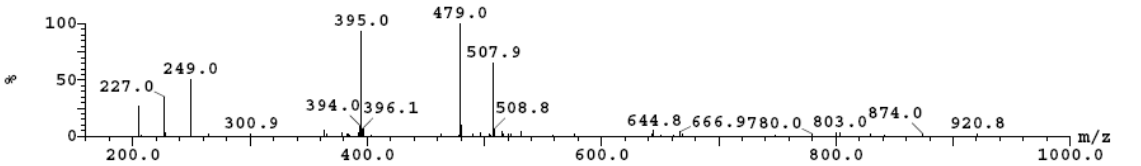
1:MS ES+
6.9e+006



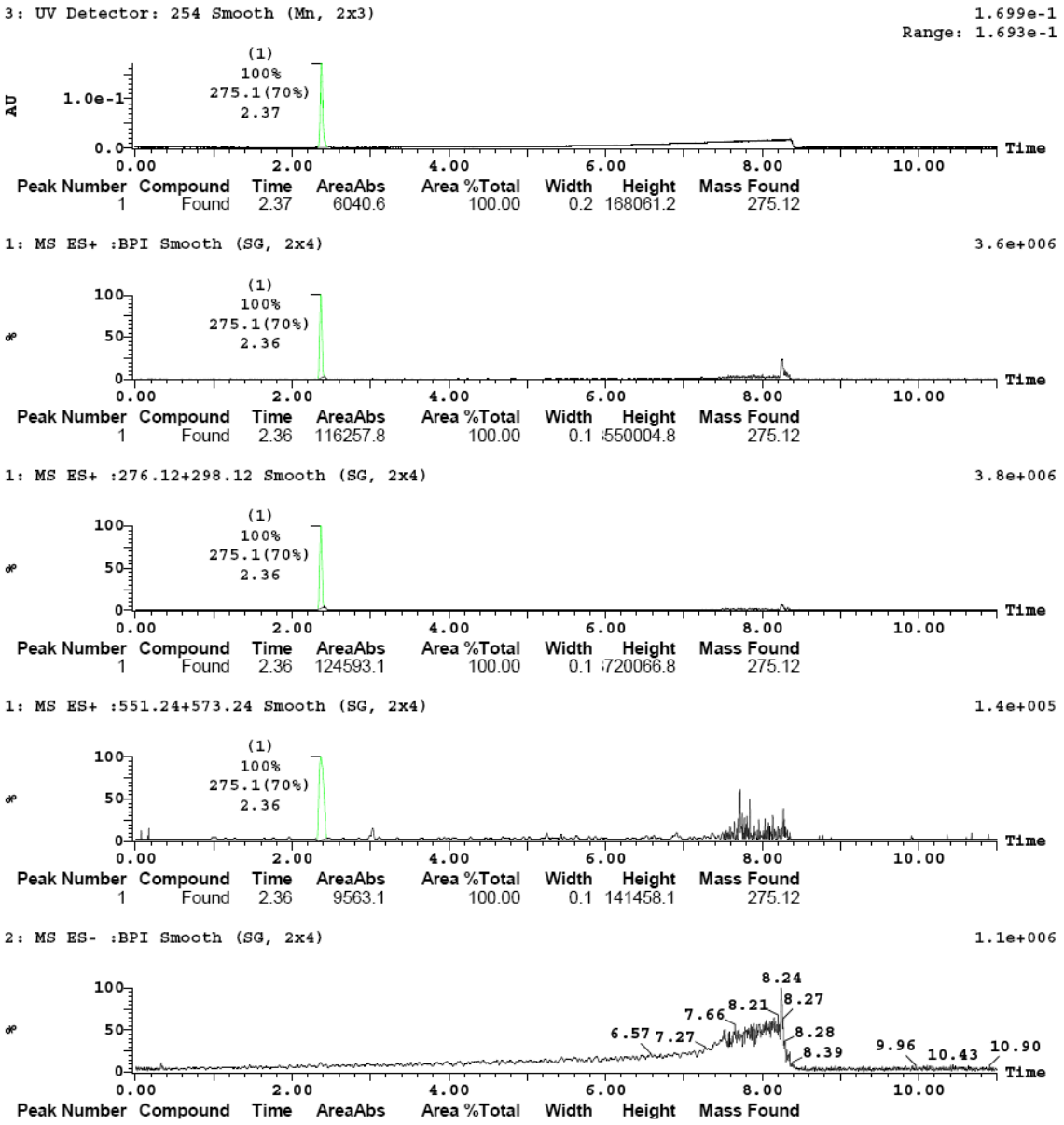
Peak ID	Compound	Time	Mass Found
4		2.49	

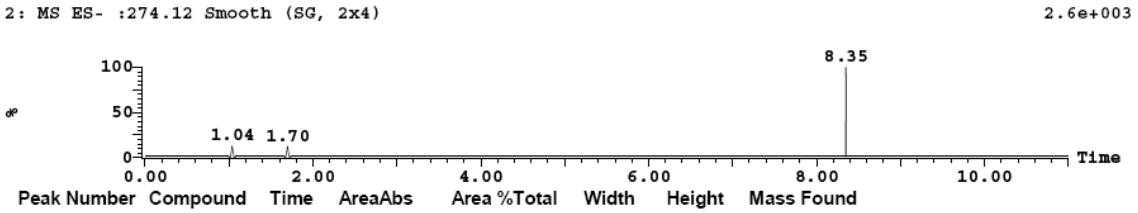
4:(Time: 2.48) Combine (518:522)

2:MS ES-
7.6e+004

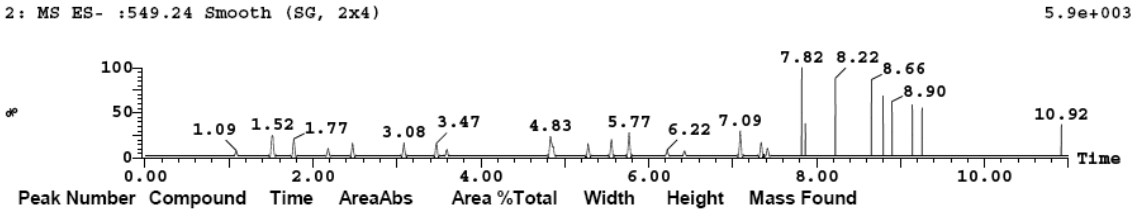


HT-LC-MS Spectrum (SOP 2200) of **9a**. UV purity: 100 %

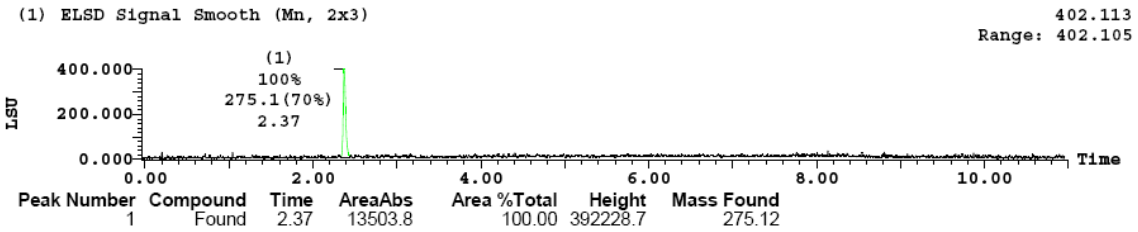




Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

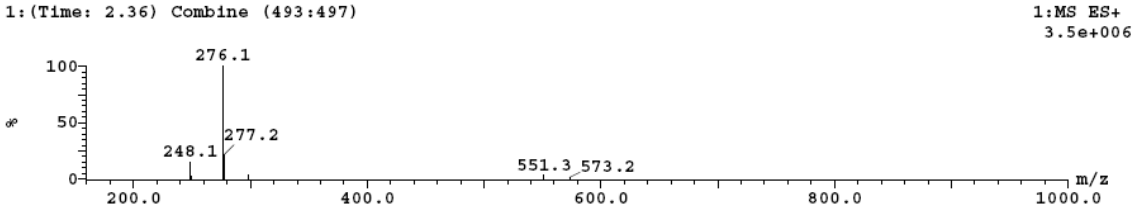


Peak Number	Compound	Time	AreaAbs	Area %Total	Width	Height	Mass Found

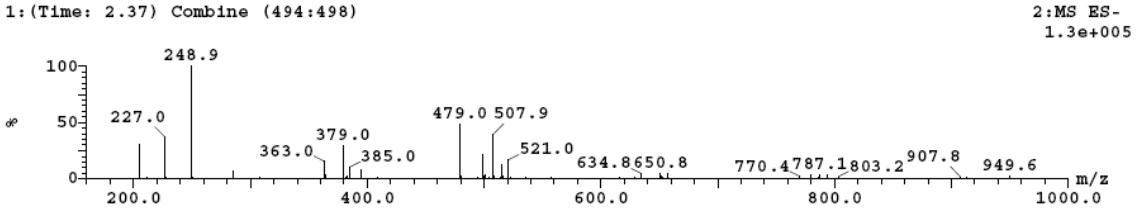


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
1	Found	2.37	13503.8	100.00	392228.7	275.12

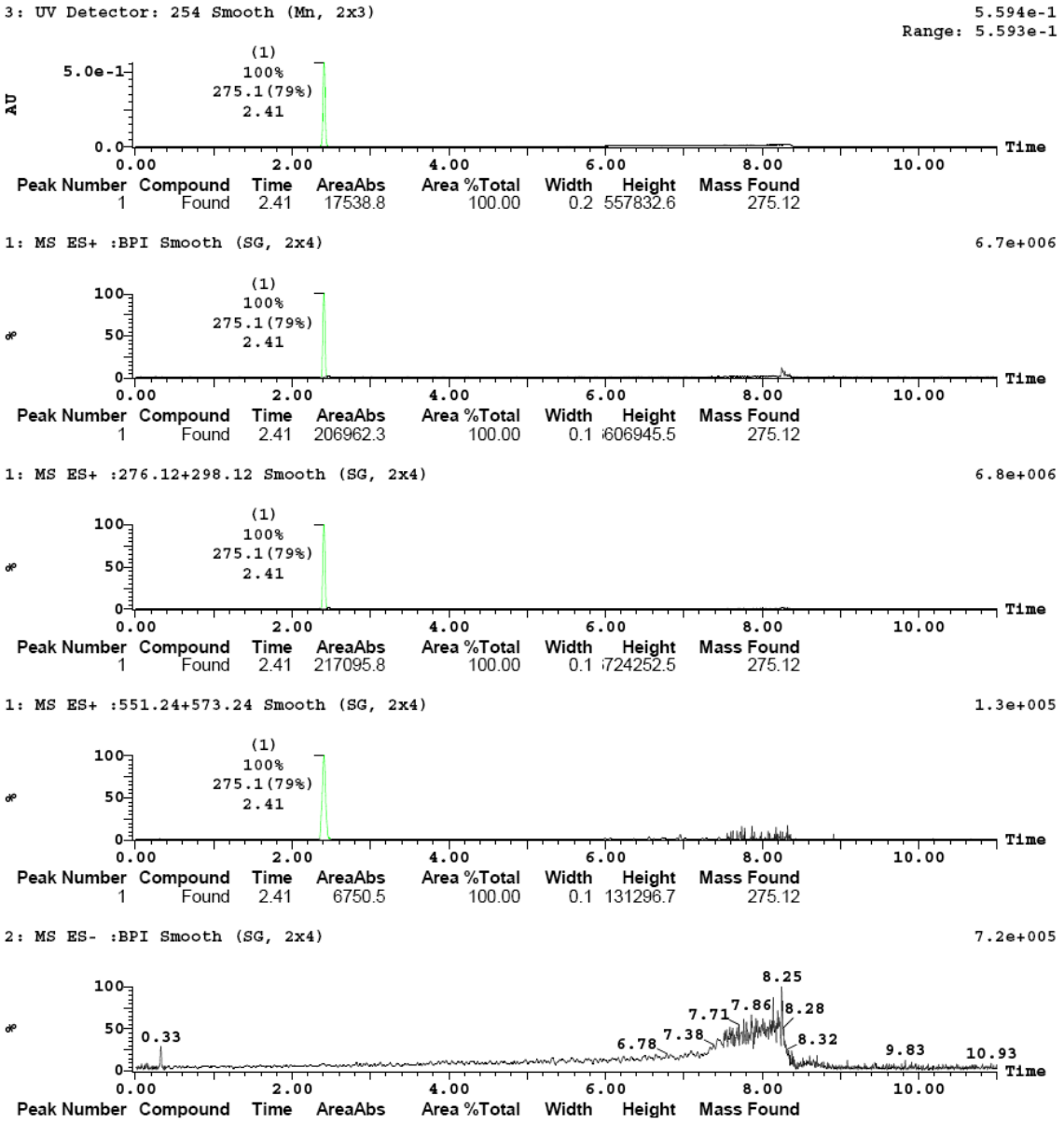
Peak ID	Compound	Time	Mass Found
1	Found	2.36	275.12

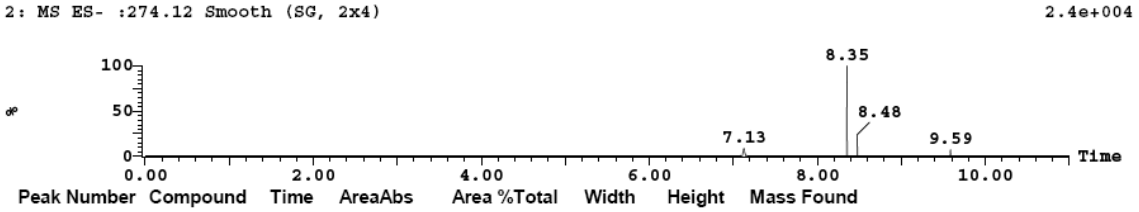


Peak ID	Compound	Time	Mass Found
1		2.36	

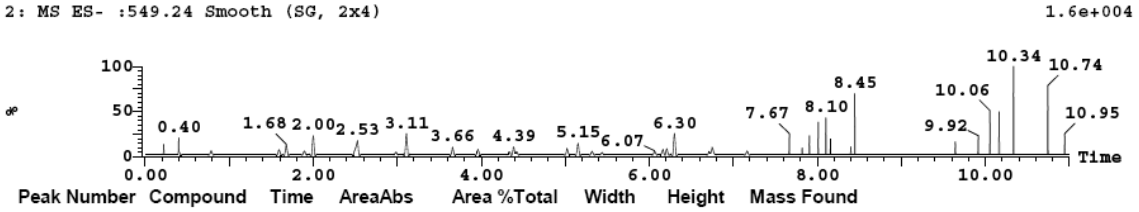


HT-LC-MS Spectrum (SOP 2222) of **9b**. UV purity: 100 %

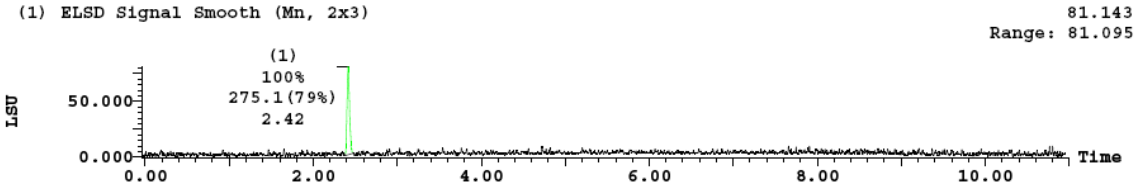




Peak Number | Compound | Time | AreaAbs | Area %Total | Width | Height | Mass Found

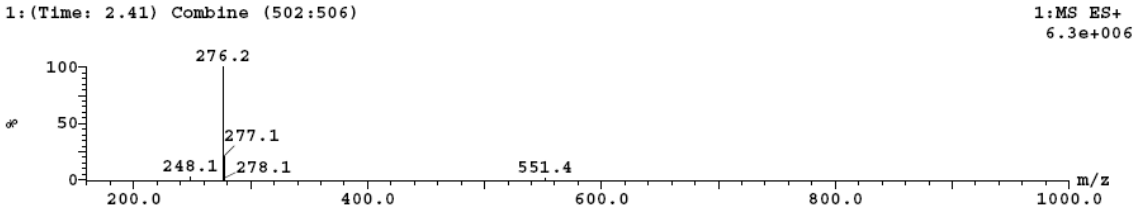


Peak Number | Compound | Time | AreaAbs | Area %Total | Width | Height | Mass Found

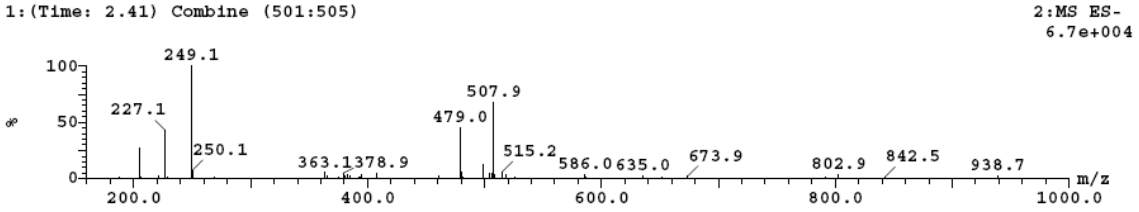


Peak Number	Compound	Time	AreaAbs	Area %Total	Height	Mass Found
1	Found	2.42	2689.6	100.00	78671.3	275.12

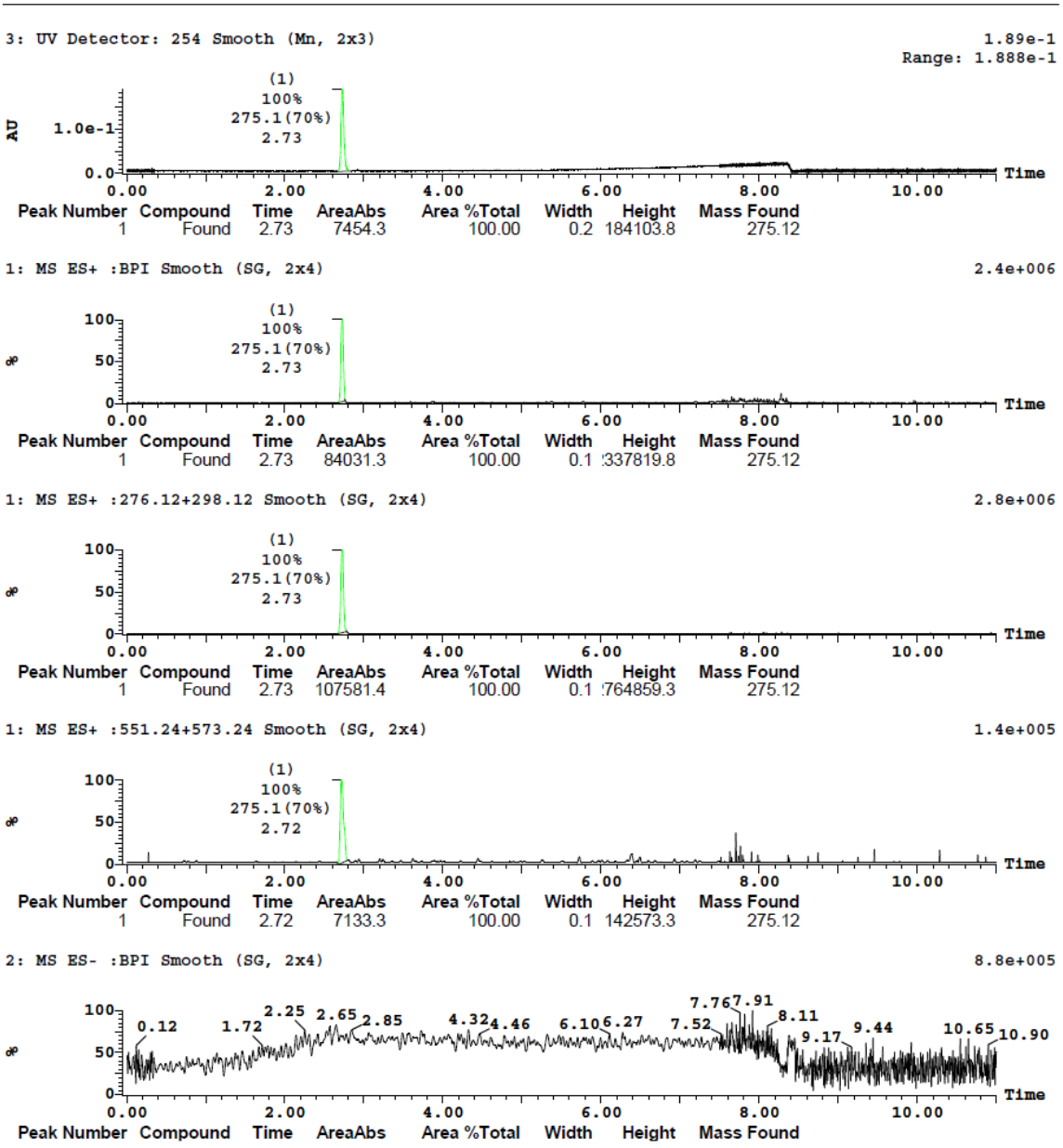
Peak ID	Compound	Time	Mass Found
1	Found	2.41	275.12

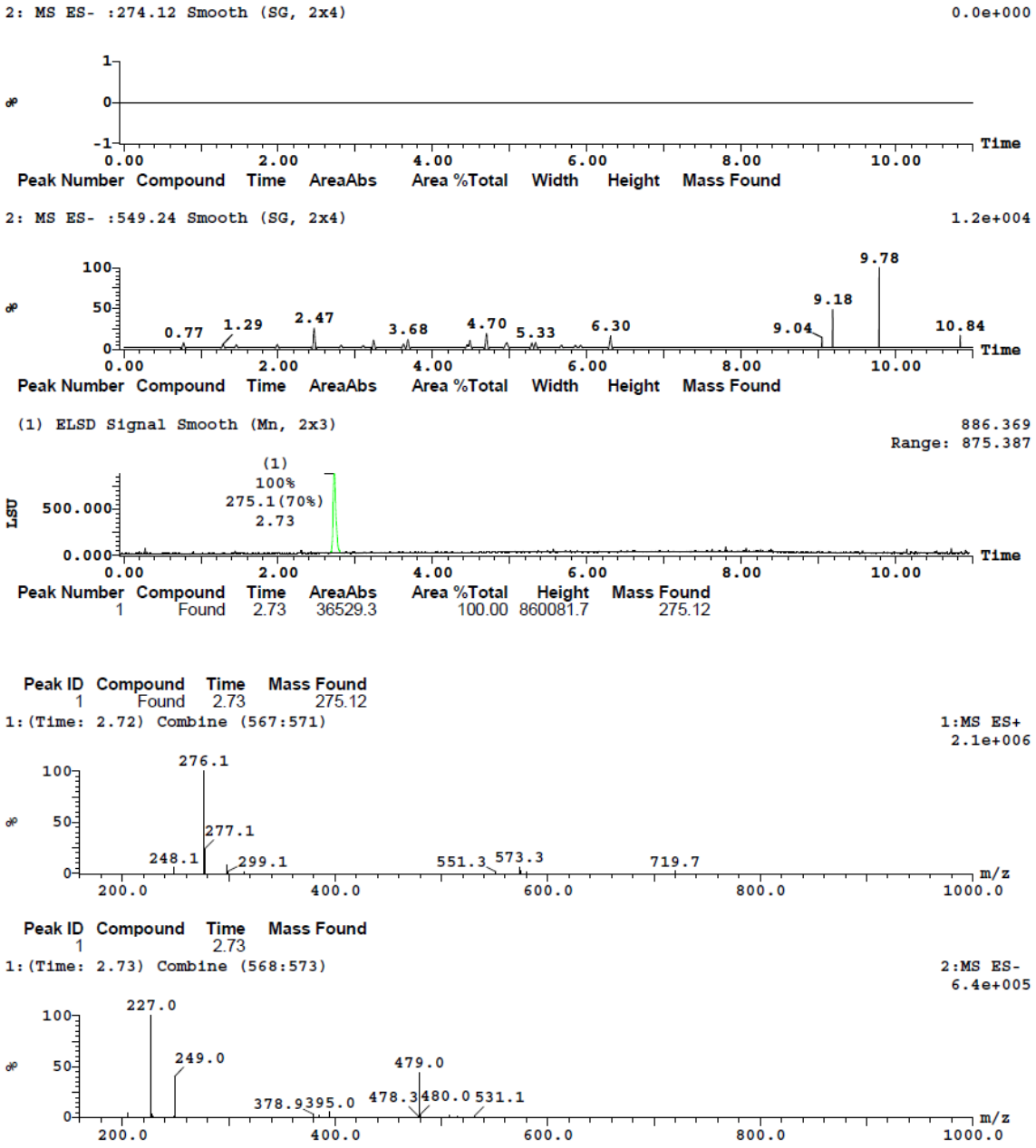


Peak ID	Compound	Time	Mass Found
1		2.41	

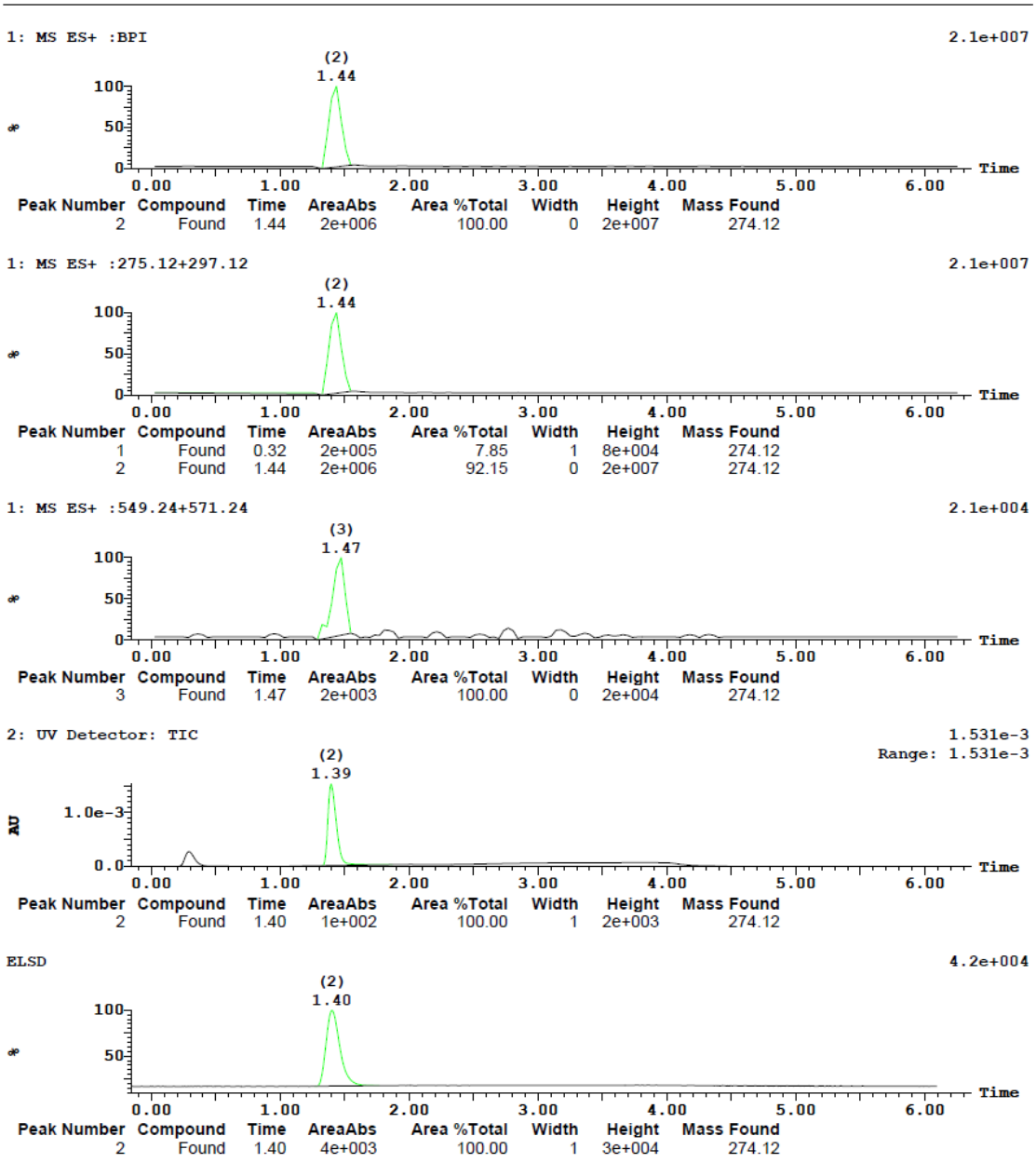


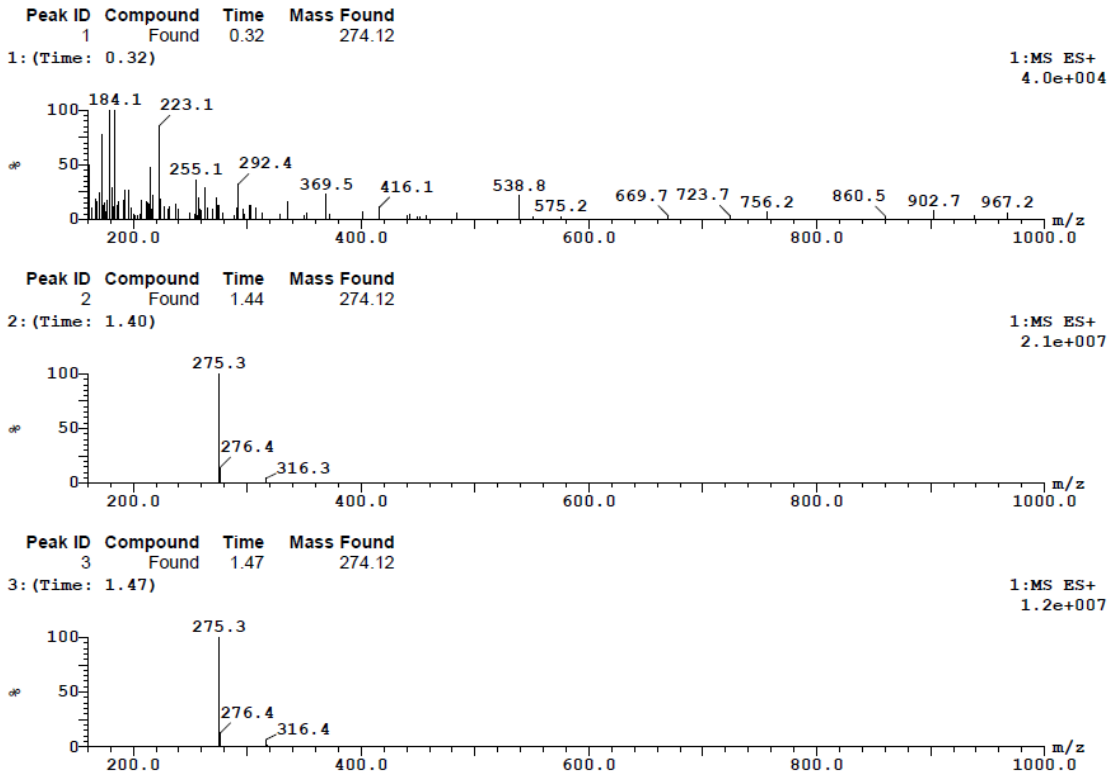
HT-LC-MS Spectrum (SOP 2200) of **10**. UV purity: 100 %





HT-LC-MS Spectrum (SOP 2222) of **11**. UV purity: 100 %




Peak ID Compound Time Mass Found
1 Found 0.32 274.12
1:(Time: 0.32)
1:MS ES+
4.0e+004
184.1
223.1
255.1
292.4
369.5
416.1
538.8
575.2
669.7
723.7
756.2
860.5
902.7
967.2
m/z
Peak ID Compound Time Mass Found
2 Found 1.44 274.12
2:(Time: 1.40)
1:MS ES+
2.1e+007
275.3
276.4
316.3
m/z
Peak ID Compound Time Mass Found
3 Found 1.47 274.12
3:(Time: 1.47)
1:MS ES+
1.2e+007
275.3
276.4
316.4
m/z

8.2. HT-LC-MS Methods for the control of identity and purity of compounds 8a-s, 9a-b, 10, and 11

Problem definition	Identity and Purity			
SOP (Standard Operating Procedure)	2200			
Methods	HT-LC-MS			
System	Waters Acquity UPLC® with PDA and ELSD			
	Waters SQD (ESI+/- and APCI+/-)			
Software	MassLynx with OpenLynx			
Column	Waters XBridge™ C8 3.5 µm			
	4.6 x 50 mm Column			
	Part No. 186003053			
Eluent	A: 99.9 % acetonitrile + 0.1 % TFA			
	B: 99.9 % water + 0.1 % TFA			
Gradient	time (min)	A %	B %	flow (mL/min)
	0	5	95	2.0
	8.00	100	0	2.0
	8.10	10	90	2.0
	8.50	5	95	2.0
	11.00	5	95	2.0
Column temperature	Room temperature			
Injection volume	3 µL			
Sample preparation	Approx. 0.1 mg were dissolved in acetonitrile + water 50/50 in an ultrasonic bath, so that the concentration was 0.5 mM.			
	If necessary, the sample was additionally diluted: 100 µL in 500 µL acetonitrile + water 5/95.			

Problem definition	Identity and Purity			
SOP	2222			
Methods	HT-LC-MS			
System	4 x Waters 1525 Binary HPLC Pump			
	2 x Waters In-Line Degasser AF			
	1 x Waters 2777 Sample Manager			
	1 x Waters 2488 Mux-UV Detector			
	4 x Waters 2420 ELS Detector			
	1 x Waters ZQ-MUX			
Software	MassLynx with OpenLynx			
Column	Chromolith® Flash RP-18e (25-2mm)			
Eluent	A: 99.9 % acetonitrile + 0.1 % formic acid			
	B: 99.9 % water + 0.1 % formic acid			
Gradient	time (min)	A %	B %	flow (mL/min)
	0	5	95	0.8
	1.7	100	0	0.8
	3.0	100	0	0.8
	3.01	0	100	0.8
	6.25	5	95	0.8
Column temperature	Room temperature			
Throughput	416 samples: approx. 11 h			

8.3. Determination of Cu and Pd contents in compound 8f

Sample preparation:	4.8 mg of compound **8f** dissolved in 4.8 mL of DMSO
Measurement:	ICP-MS
Sample introduction:	50 μL/min Meinhard sprayer, quartz cyclone spray chamber, syringe pump
Internal standard:	Rhodium
Calibration:	Addition of standard or additions calibration

Additions [μg/g]:	Cu	Pd
	5	5
	10	10
	15	15
Analytical results:	Cu	Pd
	< 2 μg/g	< 1 μg/g

9. References

[1] B. Witulski, N. Buschmann, U. Bergsträßer, *Tetrahedron* **2000**, *56*, 8473-8480.

[2] T. A. Kelly, D. W. McNeil, J. M. Rose, E. David, C.-K. Shih, P. M. Grob, *J. Med. Chem.* **1997**, *40*, 2430-2433.

[3] "Three-component synthesis of *N*-Boc-4-iodopyrroles and sequential one-pot alkynylation" E. Merkul, C. Boersch, W. Frank, T. J. J. Müller, *Org. Lett.* **2009**, *11*, 2269-2272.

[4] "Efficient one-pot synthesis of 1-aryl 1,2,3-triazoles from aryl halides and terminal alkynes in the presence of sodium azide" J. Andersen, S. Bolvig, X. Liang, *Synlett* **2005**, 2941-2947.

[5] "Rapid synthesis of bis(hetero)aryls by one-pot Masuda borylation – Suzuki coupling sequence and its application to concise total syntheses of meridianins A and G" E. Merkul, E. Schäfer, T. J. J. Müller, *Org. Biomol. Chem.* **2011**, DOI: 10.1039/C1OB05310H.